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THE R&M 2000 PROCESS AND RELIABILITY AND MAINTAINABILITY MANAGEMENT: ATTITUDES OF SENIOR LEVEL MANAGERS IN AERONAUTICAL SYSTEMS DIVISION

THESIS

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THESIS

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Abstract

The purpose of this study was to examine the attitudes of senior level managers in Air Force System Command's Aeronautical Systems Division regarding the utility of the Air Force R&M 2000 Program.

Five investigative questions were asked: 1) What is the effectiveness of existing R&M management tools as aids to performing functional management duties? 2) How are the ten integrated logistics support elements influenced by increased emphasis on R&M? 3) What priority is given to R&M 2000 goals by senior level ASD managers? 4) How satisfied are senior level ASD managers with R&M education and training, and R&M expertise within their program offices? And, 5) How effective is the R&M 2000 Program within ASD program offices, and how can this effectiveness be improved?

A survey was used to collect the research data. Findings have determined that the R&M management tools presented in the survey were moderately effective as aids to planning, organizing, directing, and controlling R&M activities. Additionally, program-specific R&M requirements had a moderate influence on the management of integrated logistics support. ASD senior managers disagreed with the priority order given the goals of R&M 2000 by HQ USAF. Also, they are not fully satisfied with the methods of R&M education and training utilized, nor are they fully satisfied with the amount of R&M expertise resident in ASD

program offices. Finally, ASD senior level managers felt the Air Force R&M 2000 program was moderately effective within ASD program offices.

Deficiencies were identified and recommendations made for improvement of the design of the survey instrument prior to its reuse for future research. Also, it was recommended that other AFSC product divisions have the same survey administered to them for comparison of results.

Appendices include a copy of the research instrument and its cover letter (Appendix A), verbal responses to applicable survey questions (Appendix B), additional data analysis support materials (Appendix C), and a comprehensive list of abbreviations found throughout this document (Appendix D).

THE R&M 2000 PROCESS AND RELIABILITY AND MAINTAINABILITY MANAGEMENT: ATTITUDES OF SENIOR LEVEL MANAGERS IN AERONAUTICAL SYSTEMS DIVISION

I. INTRODUCTION

Overview

In December 1985, the Secretary of the Air Force distributed a Fact Sheet explaining the new Air Force Reliability and Maintainability (R&M 2000) Program. In this fact sheet, explicitly stated, were the goals and objectives of this new "corporate acquisition philosophy." Its intent was to outline a new way of orienting our thinking about priorities within the acquisition world. Soon to follow were changes to AFR 800-18, Air Force Reliability and Maintainability Policy; DoDD 5000.3, DoD policies and procedures for operational test and evaluation during weapon system acquisition; and DoDD 5000.4, which establishes policies and responsibilities for R&M for major weapon system acquisition and life cycle cost management. In addition, numerous (five, to date) R&M policy letters have come from the Office of the (Air Force) Chief of Staff providing guidance, measurement standards, and personnel performance measurement criteria (19;27;28;29;30).

In his recently published book The Defense Matrix: National Preparedness and the Military Industrial Complex, retired General James P. Mullins, former Commander of Air Force Logistics Command, faults the military for its long-standing "rubber on the ramp" mentality. This, he says, has resulted in our acquiring military systems without sufficient regard for the means to insure proper operation and support. General Mullins feels Air Force acquisition leaders have established a mindset of "institutionalized mediocrity" or the ready acceptance of unreliable equipment. He feels the technology is available to give us far greater weapon system reliability, if acquisition managers only ask for it (7:109). Not without motivation for concern, this move towards focusing thinking on issues of R&M is echoed in three current studies (22;32;33) and numerous publicly acknowledged acquisition errors--the Sergeant York Gun (4;15;21), the much maligned B-1 bomber (2;13;16;20;35), and the Advanced Cruise Missile (13;31), to name a few. Ultimately, it is desired that thinking "R&M 2000" will instill in the end user, acquisition, and support communities an attitude which places R&M considerations on par with cost, schedule, and performance (37:4).

Problem Statement

No rigorous statistical study of management opinion and attitude has been accomplished since the institution of R&M 2000 as a management philosophy. Hence, no one knows if R&M

2000 has truly been accepted by the people charged with its adoption.

Justification

On 1 October 1986, HQ USAF directed the Air Force Institute of Technology (AFIT) to maintain an Air Force Center of Excellence for Reliability and Maintainability (CERM). The Center's charter is

> to develop R&M concepts, theory, and techniques and to provide R&M consulting services to Air Force organizations. (10:7)

This was one of the first research projects to investigate the impact of R&M 2000 on the management of acquisition programs initiated under this tasking. It is responding to senior Air Force leadership's desire to keep informed on how the message of increased emphasis on R&M is being received, accepted, and implemented in the field.

Research Question

What are the attitudes of senior level managers in Aeronautical Systems Division (ASD) regarding the utility of the Air Force R&M 2000 Program?

Investigative Questions

The questions to be investigated in this research are:

1. How do senior ASD managers feel about the effectiveness of existing R&M management tools as aids to performing functional duties?

2. How are the ten integrated logistics support elements affected by increased emphasis on R&M?

3. What priority is given to R&M 2000 goals by senior level ASD managers?

4. How satisfied are senior level ASD managers with R&M education and training, and R&M expertise within their program offices?

5. How effective is the Air Force R&M 2000 program within ASD program offices, and how can this effectiveness be improved?

Research Propositions and Hypotheses

This study addresses the five research objectives through three propositions and two independent hypotheses which directly support two of the research objectives. The proposition-null hypothesis relationships investigated in this study are:

Proposition 1. The tools of R&M management addressed in this research study have had little or no effect on achieving R&M requirements in ASD program offices.

Null Hypothesis 1. R&M management tools associated with the planning function have had little or no effect on achieving R&M requirements in ASD program offices.

Null Hypothesis 2. R&M management tools associated with the organizing function have had little or no effect on achieving R&M requirements in ASD program offices.

Null Hypothesis 3. R&M management tools associated with the directing function have had little or no effect on achieving R&M requirements in ASD program offices.

Null Hypothesis 4. R&M management tools associated with the controlling function have had little or no effect on achieving R&M requirements in ASD program offices.

Proposition 2. Program-specific R&M requirements have had little or no influence on the management of integrated logistics support.

Null Hypothesis 5. Program-specific R&M requirements have had little or no influence on management of maintenance planning.

Null Hypothesis 6. Program-specific R&M requirements have had little or no influence on management of manpower and personnel.

Null Hypothesis 7. Program-specific R&M requirements have had little or no influence on management of supply support.

Null Hypothesis 8. Program-specific R&M requirements have had little or no influence on management of support equipment.

Null Hypothesis 9. Program-specific R&M requirements have had little or no influence on management of technical data.

Null Hypothesis 10. Program-specific R&M requirements have had little or no influence on management of computer resources.

Null Hypothesis 11. Program-specific R&M requirements have had little or no influence on management of training.

Null Hypothesis 12. Program-specific R&M requirements have had little or no influence on management of design interface.

Null Hypothesis 13. Program-specific R&M requirements have had little or no influence on management of facilities.

Null Hypothesis 14. Program-specific R&M requirements have had little or no influence on management of packaging, handling, storage, and transportation.

Null Hypothesis 15. There is no difference in the rank order ASD senior level managers and HQ USAF leadership give to the goals of the R&M 2000 Process.

Proposition 3. An adequate level of R&M education and training is not available within ASD program offices.

Null Hypothesis 16. An adequate supply of skilled and experienced R&M personnel does not exist within ASD program offices.

Null Hypothesis 17. An immediate need for R&M education and training exists within ASD program offices.

Null Hypothesis 18. The R&M 2000 Process has had little or no effect on the management of R&M in ASD program offices.

Figure 1 graphically depicts the objective-proposition-null hypothesis relationships described above.

Scope

There are five Air Force Systems Command product divisions involved in the acquisition of new weapon systems and/or support equipment, avionics, etc. They are:

1. Aeronautical Systems Division - responsible for directing acquisition of aircraft; and missiles, engines, simulators, electronic warfare equipment, and improved avionics for these new and existing air frames,

2. Electronic Systems Division - responsible for the acquisition of electronic systems and equipment for command control communications and intelligence functions undertaken by the United States Air Force,

3. The Ballistic Missile Office - responsible for the acquisition of all major end items and sub-systems for the Air Force ballistic missile fleet,

4. Space Division - responsible for the acquisition of space-based communications, navigation, meteorological, and surveillance systems; as well as spacecraft, launch vehicles, and all associated support equipment. And,

5. Armament Division - responsible for the acquisition of conventional air armament, as well as the test and

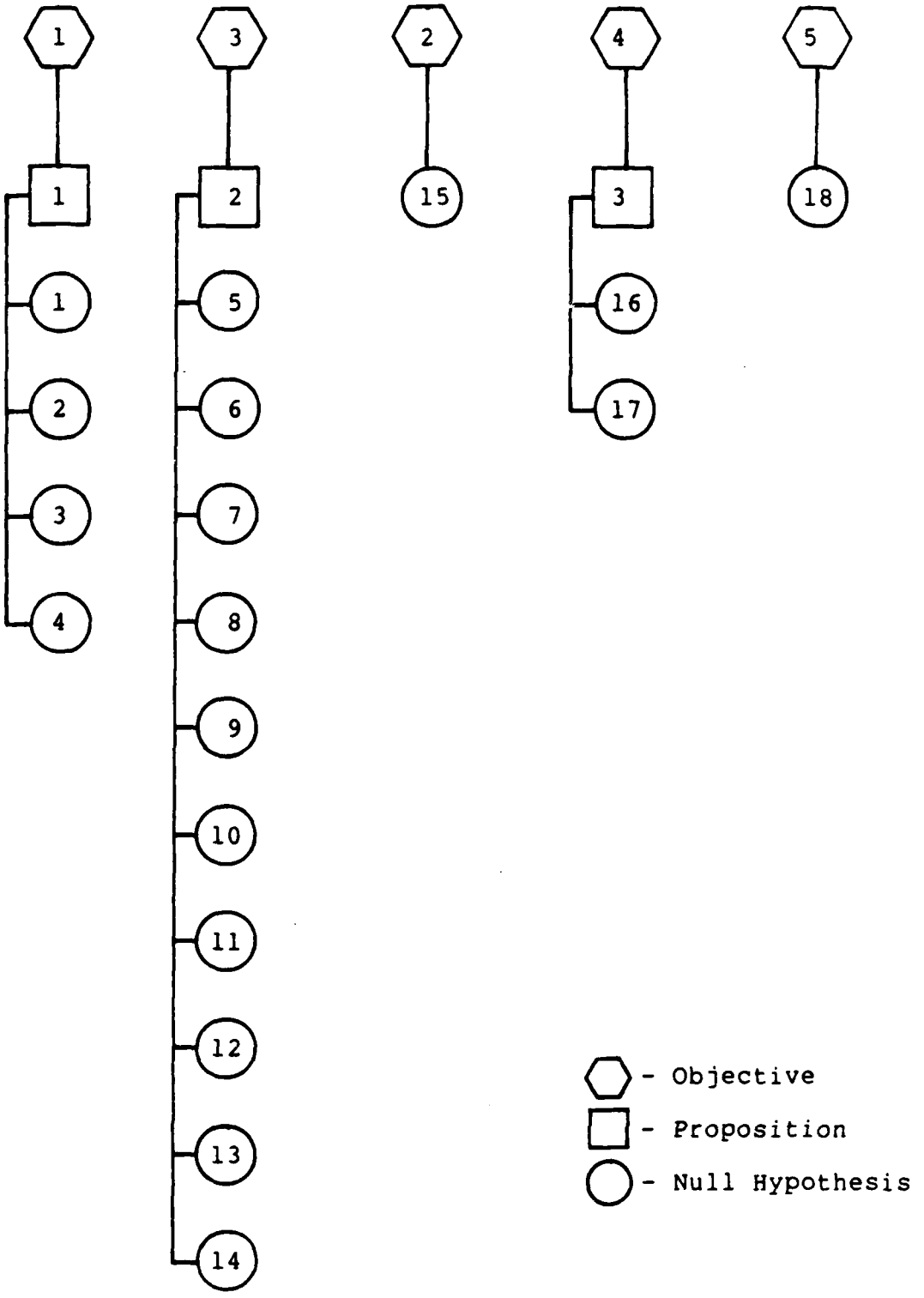

Figure 1. Objective-Proposition-Null Hypothesis Relationships

evaluation of armament and electronic combat systems and associated equipment (18:205).

Not mentioned are the major command units and headquarters directorates responsible for monitoring or managing weapon system acquisition. Nor is mention made of the Air Force Operational Test and Evaluation Center, the special operating agency responsible for monitoring or performing the operational testing of all newly acquired systems and modernization of existing systems.

Each of these organizations has a branch responsible for managing control of reliability, maintainability, and integrated logistics support concerns. To examine attitudes across the full breadth of this universe would be a monumental undertaking beyond the time constraints placed on this researcher.

Since this is an exploratory research effort in support of AFIT's role as the Air Force's CERM and since ASD is located at Wright-Patterson along with AFIT, it seemed the natural choice for keeping the scope of the research at a manageable level. Proven successful, follow-on studies could be performed using the same research instrument within these other organizations.

II. LITERATURE REVIEW

Introduction

Three areas were emphasized in the literature review. First, the historical development of the R&M 2000 principles. Here it was shown how senior DoD leaders arrived at what they consider to be essential "building blocks" (25:11) of the R&M 2000 management process. Next, four previously accomplished research endeavors were reviewed which assessed/critiqued past R&M management practices. One interesting finding was that the recommendations made by the researching agencies closely resemble the aforementioned building blocks of the R&M 2000 process. And lastly, a review of accepted principles of attitude theory, as a foundation for the direction of this research project, was undertaken.

Historical Development of R&M 2000 Principles

In January of 1981, the DoD took a new tack with respect to management of both day-to-day operations and the business of weapon system acquisition. Increased military spending was a reality as a result of the Reagan Administration's push for a build-up in the nation's defense and the modernization of strategic forces. Under the direction of Secretary of Defense Casper Weinberger and Deputy Secretary Frank Carlucci, a "plan of action" was

devised to assist the acquisition community in managing this increased activity. The theme of this new guidance was successful acquisition of a sufficient quantity of new equipment coupled with an "increase in the quality of the acquisition community's effort...as well," (23:5).

On 30 April 1981, Deputy Secretary Carlucci published a memorandum with instituted the Defense Acquisition Improvement Program. The objectives of the program were

> to reduce costs, to make the acquisition process more efficient, to increase the stability of programs, and to decrease to time it takes to acquire military hardware. (23:5)

Secretary Carlucci published 32 initiatives (Actions) designed to guide the DoD towards accomplishing these goals. To highlight the requirement for increased emphasis on quality, Secretary Carlucci points out that

> Improved readiness is a primary objective of the acquisition process, of comparable importance to reduced unit cost or reduced acquisition time. Resources to achieve readiness will receive the same emphasis as those required to achieve schedule or performance objectives.
> -DEPSECDEF Memorandum, 30 April 1981. (6:11)

To this end, five of the 32 can be directly related to the issue of reliability and maintainability. They are:

1. Action 9--System Support and Readiness,
2. Action 12--Funding for Test Hardware,
3. Action 16--Contractor Incentives for Support,
4. Action 30--Logistics and Support Resources, and
5. Action 31--Improved Reliability and Support (5:7)

Actions 9 and 31 require identifying readiness objectives for a new weapon system very early in the acquisition program, that obtaining these objectives is tied directly to program milestones, and that adequate funding is available to ensure that reliability and maintainability is designed and built into the system. Action 16 directs the program offices to employ contractual incentives for obtaining reliability and maintainability in design. This requirement was re-emphasized in an additional memorandum issued in August 1981 (36:6). This action also gave rise to an unwritten requirement for logisticians to have a critical role in acquisition planning much sooner than normally accepted (36:6). Action 30 increases program manager involvement in supportability decisions on his program. And Action 12 ensures that adequate test articles are made available early in the acquisition process (5:9)(6:11). It is generally understood that the Defense Acquisition Improvement Program will continue to be emphasized through strict enforcement of its initiatives for some time to come (5:10).

Defense industry executives have taken a hard look at this new acquisition program. They have duly noted the less than enthusiastic way acquisition managers have addressed supportability issues in the past (37:5-6). They also note that it will be in the DoD's best interest to spend the additional dollars required to improve supportability at the

"front-end" of the acquisition in order to reap the rewards of decreased total life cycle costs in the long run (37:6-7).

Previous Research

Prior to the institution of the Defense Acquisition Improvement Program, numerous studies were undertaken to examine operations within the weapon system acquisition arena. Here are but four of those studies and there results/recommendations.

The AFALD Study. In September 1978, Lt Gen John G. Albert, then Commander of the Air Force Acquisition Logistics Division (AFALD, now the Air Force Acquisition Logistics Center--AFALC), directed a survey be administered to all Deputy Program Managers for Logistics (DPMLs) as a means of ascertaining to what extent contractual reliability requirements were being adhered to in ongoing Air Force acquisition programs (32:1). It is the responsibility of the DPML to ensure issues pertaining to reliability, maintainability, and integrated logistics support on his program are not overlooked or shortchanged throughout the acquisition process. The results of that study highlighted deficiencies in three areas:

1. A general lack of capability to accurately identify in which stage of the acquisition process a program actually was. As a result, requirements for system reliability which

were to be emphasized at particular stages were often overlooked,

2. A general inability to differentiate between the numerical measures of reliability and maintainability, leading to potential ineffective management of the reliability issues pursuant to the program, and

3. A lack of knowledge as to which reliability tasks are appropriate for emphasis in a given stage of the acquisition process (32:4-25).

It was also pointed out that continuing emphasis on education in the area of R&M was required. Several documents, sources of classroom education, and the need to tap the expertise of experienced acquisition personnel were cited as means of remedying the situation (32:25).

The DSB Study. In 1981, a study of the operational readiness of high performance systems was published by the Defense Science Board (DSB). The study recommended a need to design reliability into systems from the start, and to mature that capability prior to full-rate production (33:Sec I,1). It was also noted that as acquired systems became more and more complex, DOD would have to demand the acquisition process put increased management emphasis on R&M issues (33:Sec I, 1). Although the Carlucci Initiatives (36:7) took the first steps in this direction, the demonstrated progress of the acquisition community in keeping R&M emphasis high indicated less than full support

of the program (33:Sec I, 1-2). In their defense, however, it was noted that accelerating acquisition programs to respond to the (Reagan) Administration's objective of fielding hardware faster was perturbating this already bad situation (33: Sec I, 2).

The OSD/IDA Study. In November 1983, the Institute for Defense Analyses (IDA) undertook an R&M study for the Office of the Secretary of Defense (OSD) in response to the DSB findings. As a result, ten areas of improvement were recommended. Among the most critical of these were the following seven:

1. The R&M Demonstration Program--wherein the contractor is required to physically demonstrate that time and procedures required for system maintenance are as accurate as outlined in system specifications, and that personnel of the designated maintenance skill level(s) are capable of performing the task,

2. R&M Standards--An up front, predetermined level of R&M performance is established during the weapon system concept validation stage, supported by inputs from the user and acquisition community logisticians.

3. Management Incentives--A means of rewarding program office managers for focusing on issues pertaining to R&M in their interactions with contractors.

4. New System Maturation--wherein a plan is established to track the performance of those systems whose

reliability is heavily dependent upon "new and evolving technology" after it is fielded for correcting deficiencies resulting from previously unforeseen operational demands,

5. Collection and Use of Field R&M Data--by system development engineers. In the past, little attention was given to the suggestions and recommendations of users as to ways in which either initial system design or design changes can facilitate weapon system field support,

6. R&M Training for Managers--Making ample and productive use of the myriad of opportunities for providing acquisition community personnel with professional education and training in R&M management.

7. Diagnostics--Placing greater emphasis on reducing the deficiencies in reporting accuracy and "false alarms" with respect to built-in test equipment and subcomponents (33:Sec II).

The ASD Survey. In November 1987, ASD completed an industry survey which yielded information as to policies, practices, and procedures the defense contractor community was using to increase the emphasis put on R&M - the major focus being placed on engineering areas. They then compared these findings to their in-house policies, practices, etc., and identified several disconnects. Areas where improvement was recommended were:

1. More internal training on R&M principles and applications,

2. Increased exposure of contractors to the use of weapon systems in the operational environments,

3. Integrating logistics support requirements in the system design process,

4. Increased quality control for replacement parts, and

5. Pursuing aggressive implementation of integrity programs, the goal of which is to design a structure that does not break down -- as opposed to the traditional Mean Time Between Failure goal. Critical to this approach is the integration of R&M requirements into the integrity program approach (22).

In short, the theme common to all these recommendations is the need for increased user participation and earlier emphasis on R&M requirements in system design and support, and improved education and training.

The R&M 2000 Process

Following is an overview of R&M 2000, the Air Force's initiative to ensure its acquisition managers are assisted as much as possible in the management of weapon acquisition in accordance with the Carlucci Initiatives of the Defense Acquisition Improvement Program. Air Force R&M 2000 goals, in order of importance, are:

1. Increase Combat Capability--by using R&M as a means of improving performance over time,

2. Increase Survivability of the Combat Support Structure--by as much as possible "breaking the logistics tether,"

3. Decrease Mobility Requirements Per Unit--a combat support structure that is not needed does not have to be moved or mobilized,

4. Decrease Manpower Requirements Per Unit of Output--the fewer the number of personnel required to support a weapon system, the more personnel there are available for duties elsewhere in the support structure. This gives rise to the concept of viewing reliability and maintainability as a "force multiplier," and

5. Decrease Costs--through well thought out design and endeavoring to do things right the first time (25:2-7).

To assist Air Force managers in attaining these goals, five management principles, and 21 "building blocks" to support those principles were established. They are:

1. Involvement--highlighting that change cannot take place without management's commitment to it,

2. Motivation--of industry to capitalize on industrial capability to increase combat capability. The three building blocks associated with this principle are:

a. Source Selection--R&M must be singled out as a specific evaluation criteria.

b. Performance-based Progress--low performance means no money!

c. Incentives (during the design phase) and Warranties (during field performance).

3. Requirements--for operational performance must be communicated clearly. Associated building blocks are:

a. Clear Requirements--ensure they are mission-based and operationally oriented.

b. Technician Transparency--attempting to reduce the number of specialists required to maintain increasingly capable systems.

c. Simplification--designing a system/subsystem so that it will be easier and cheaper to produce.

d. Modularity--packaging components and software into self-contained units.

e. R&M Plans--should reflect an organization's goals and objectives, and the strategy for attaining them.

f. Company Policy and Practices--documenting the contractor's commitment to R&M.

4. Design and Growth--consider R&M needs from the start, and allow them to mature with the system. In order to support this principle, provided are:

a. Systems Engineering Process--committing the acquisition team to delivering products that meet user needs at a reasonable cost.

b. Allocation and Prediction--establishing a hierarchy of requirements for designers, then making and tracking estimates as to whether or not requirements will be achieved.

c. Analysis--must be a key activity in design and development.

d. Growth Management--a "stair step" approach to managing/tracking the growth of R&M capability in a weapon.

e. Parts Selection--use only the best available.

f. Derating--restricting stresses on components to levels below their rated operational limits.

g. Computer-Aided Tools--make use of them in order to increase efficiency in the design and production processes.

h. Test, Analyze, and Fix--must be an ongoing methodology whereby deficiencies are analyzed, corrected, and retested as they occur to ensure failure causes are completely removed. And,

5. Preservation--ensuring inherent R&M capabilities are preserved during production and maintained in the operational environment. Supporting this principle are:

a. Variability Reduction Program--with a goal of developing a highly capable manufacturing process which produces uniform, defect-free items which meet design requirements.

b. Environmental Stress Screening--simulating assembly operating environment conditions in order to precipitate failure in the factory and eliminate failure in the field.

c. System Testing--the continuous assessment of performance in actual or simulated conditions.

d. Feedback--facilitating the flow of information from the field to design engineers for assessing R&M performance and for building a database for future product and/or process improvement (25:11-103).

Figure 2, taken from the R&M 2000 Process pamphlet, shows the overall relationships between the five management principles and 21 building blocks. Top management involvement is the "blanket" which envelopes all other principles and building blocks, emphasizing its importance to the successful implementation of the others.

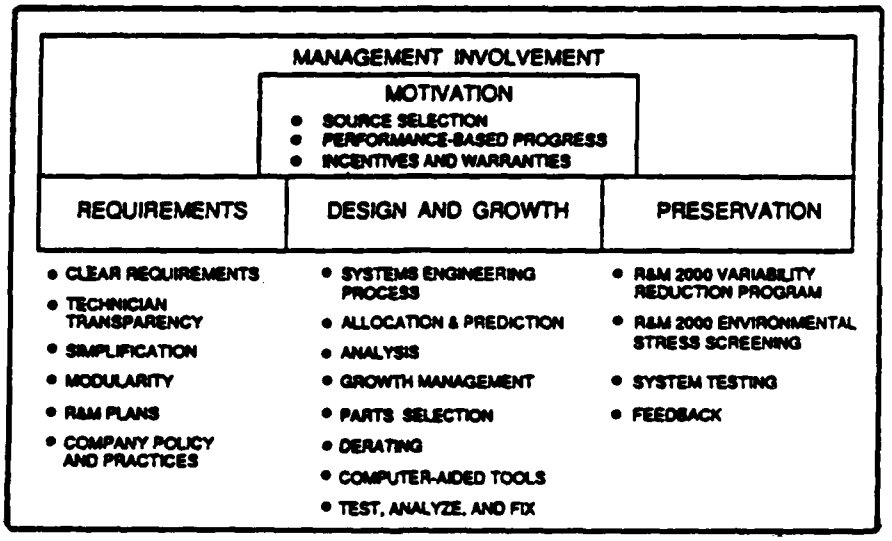

Figure 2 - The R&M 2000 Principles and Building Blocks

Attitude Theory

Since the purpose of this study is to obtain information on the attitudes and opinions of senior level ASD managers, a working familiarity with accepted theory detailing what constitutes attitudes and how they are developed is a prerequisite to construction of a useful research tool. According to Doobs, attitude is defined as

> . . . an implicit response with drive strength which occurs with the individual as a reaction to stimulus patterns and which affects subsequent overt responses. (11:43)

He further cautions on using attitudes alone as a predictor of behavior (1:9)(11:44).

Peak defines attitude as a product of our perceptions displaying affective properties as manifest externally by our likes and dislikes, or by what we favor or not favor (26:67).

Fishbein and Ajzen agree in context with the above definitions and go a step further to subdivide attitude into three components: 1)a cognitive component dealing with the individual's beliefs and ideas; 2)an affective component, referring to the individual's feelings towards the issue at hand, and 3)a behavioral intention component, which refers to how the individual will tend to behave towards the person, object, etc., as a function of their affective component (9:75). Actual behavior is the end result of the translation of behavioral intention into action.

Crespi takes a similar view defining attitude as "predispositions to [consistently] behave in specific ways to specific stimuli" (8:10). He goes on to state that because of the non-observability of predispositions, a means of inferring attitude must be developed. He, therefore, builds on his previous definition by extrapolating that an attitude can be considered "an inferred underlying structure of cognition, frame of reference, evaluation, and affect" (8:10). By cognition, Crespi means an "awareness and knowledge" of the subject (8:5). Frame of reference refers to the level of significance the subject has in the mind of the individual (8:6). Evaluation accounts for the positive or negative reaction an individual has when confronted by the subject (8:7). And finally, affect can be considered as the measure of magnitude of that positive or negative reaction (8:5).

Based upon the author's consolidation of the above mentioned experts' definitions of attitude, the following operational definition of attitude was developed for use in this research:

> The inferred predisposition of an individual towards a given subject as overtly manifest by response to various questions on the subject; assumed to be the product of the individual's beliefs, ideas, values, and experience.

The challenge was to design the research instrument to gather as much information as possible on respondents' "underlying structures of cognition, frame of reference,

evaluation, and affect" in hopes of building a legitimate word picture of attitudes towards the R&M 2000 process and its management.

III. METHODOLOGY

Introduction

Ex post facto research was conducted through use of a mail questionnaire (survey). In granting their approval to perform this research, ASD requested that as little time as possible be taken from the daily schedules of all respondents. As a result, the survey method was selected.

Table I shows a breakdown of survey questions and the propositions and null hypotheses they serve to answer, as well as the associated level of data each question provides. The survey instrument is presented in Appendix A. Formal approval for its use was granted by the Air Force Military Personnel Center (AFMPC). ASD Headquarters subsequently granted approval for its distribution.

The Population

For the purpose of this study, the population was defined to address senior level ASD managers, including military and civilian managers assigned to the 168 ongoing ASD acquisition programs who hold the positions of program manager/director, deputy program manager for logistics, director/deputy for engineering, deputy for test and evaluation, or integrated logistics support manager. At present, this population numbers approximately 600.

TABLE I

SURVEY QUESTION ASSIGNMENTS TO PROPOSITIONS AND HYPOTHESES

Prop. #	Hypo. #	Ques. #	Area Addressed	Level of Data
1	1	1a - 1g	The Planning function	Interval
	2	1h & 1m	The Organizing function	Interval
	3	1i, 1l, 1n & 1o	The Directing function	Interval
	4	1j, 1k, 1p - 1u	The Controlling function	Interval
2	5	2a	Maintenance Planning	Interval
	6	2b	Manpower & Personnel	Interval
	7	2c	Supply Support	Interval
	8	2d	Support Equipment	Interval
	9	2e	Technical Data	Interval
	10	2f	Computer Resources	Interval
	11	2g	Training	Interval
	12	2h	Design Interface	Interval
	13	2i	Facilities	Interval
	14	2j	Packaging, Handling Storage, & Transport-ation	Interval
	15	3	The ranking of R&M 2000 objectives	Ordinal
3	16	6	R&M skill/experience level	Ordinal
	17	7	Need for R&M education & training	Ordinal
	18	8	Effectiveness of the R&M 2000 process	Interval

The Sample

The sample contained members of the population assigned to the specific duties mentioned above. ASD approval for distribution of the survey was contingent upon limiting the sample to include only the 16 major system program offices. What this resulted in, therefore, was a non-probability judgement sample of 62 possible respondents. The use of judgement sampling was considered appropriate in this situation (12:280) due to the exploratory nature of the research. Additionally, non-probability sampling is considered appropriate if the entire population is not available for study (12:279). Given the limitations placed on this study by ASD, this was also a valid point.

Since the names of all sample members were known, surveys were distributed through ASD's Office of the Chief of Staff. Completed questionnaires were return mailed to the author.

Validity

Internal. During survey development, several experts in the area of R&M were given the opportunity to critique and recommend changes to ensure the instrument measured what it was intended to measure. This expert opinion was gleaned from the faculty of the Air Force Institute of Technology School of Systems and Logistics (AFIT/LS), the Air Force Acquisition Logistics Center, and the ASD Headquarters staff. Through this process, adequate coverage of the

problem by the survey instrument was ensured (12:95). Also validated in this fashion was the survey design itself (12:95) via AFIT/LS faculty assigned to the Behavioral Sciences department. AFMPC was the final validating authority.

External. Prevention of respondent exposure to the survey prior to its distribution, selection of respondents from the same AFSC product division, and the guarantee of anonymity enabled the author to "generalize findings to and across [population] times, settings, and persons" (12:118).

Statistical Tests

The hypothesis testing was performed using SAS (34) and Lotus 1-2-3 (3). For testing purposes, the traditional null/alternate hypothesis relationship was used (24).

Comparison of Means, Medians, and Modes. The Lickert scale provided interval data capable of using the sample mean as both a measure of central tendency and test statistic. Table II shows the breakdown of numeric and contextual values for the survey Lickert scale. However, in order to avoid inadvertently overlooking abnormal data dispersions (such as a bimodal distributions) prior to performing the mathematics of calculating a mean, the median and mode were first ascertained (24:57-87). If reasonably close, or if bimodality did not exist, then the mean was used. If not, then an attempt was made to find why the abnormal dispersion existed.

TABLE II

MEANING OF LICKERT SCALE VALUES

Numeric Value	Contextual Meaning
0.00 - 1.75	little or no influence (or effect)
1.76 - 3.50	minimal influence (or effect)
3.51 - 5.25	moderate influence (or effect)
5.26 - 7.00	significant influence (or effect)

This procedure was applied to questions relating to null hypotheses 1 through 14, and 18. Given a reasonably normal distribution, total sample means were calculated using the formula:

$$\bar{X} = \frac{\sum X_i}{n} \qquad (24:60)$$

where x_i is the ith measurement and n is the number of sampling units from stratum i. Total sample standard deviations were calculated using the formula:

$$S = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n - 1}} \qquad (24:76)$$

The means and standard deviations were used in the hypothesis testing. The associated test statistic was a z-value calculated using the formula:

$$Z = \frac{\bar{X} - \mu_o}{\sigma_{\bar{x}}} \qquad (24:293)$$

This z-value was compared to a z_α -value obtained from a normal distribution table of z-values. The z_α-value was a constant 1.28, which reflects an alpha (α) of 0.10. The calculated z-value must be greater than the z_α-value in order for the null hypothesis to be rejected (24:293). Table III lists the null/alternate hypothesis pairs to be tested for acceptance/rejection in support of null hypotheses 1 through 14, and null hypothesis 18.

Thurstone's Case V Scaling. Used for Hypothesis 15, this technique permits construction of a unidimensional interval scale using responses obtained from such tests as paired comparisons. Two assumptions accompany use of this model. They are:

1. The variance between items paired for comparison is the same for all item pairs, and

2. The manner in which the respondent makes the selection of one of the items in a pair is the same each time a selection is made (8:180-182).

An R* value was calculated as a function of a Thurstone Z value obtained from a supplied chart. The Z values were determined as a result of the proportionate number of times a given item was preferred over all other alternatives. Based on R* values calculated for each of the comparisons, an interval rank ordering was accomplished (8:182-185).

From analysis of this rank ordering it was determined if null hypothesis 15 was accepted or rejected.

TABLE III

Null/Alternate Hypotheses Used For Tests

Null Hyp	Null Hypothesis Statement	One-Tailed Test	Test Statistic
1	R&M management tools associated with the planning function have had little or no effect on achieving R&M requirements in ASD program offices.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
2	R&M management tools associated with the organizing function have had little or no effect on achieving R&M requirements in ASD program offices.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
3	R&M management tools associated with the directing function have had little or no effect on achieving R&M requirements in ASD program offices.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
4	R&M management tools associated with the controlling function have had little or no effect on achieving R&M requirements in ASD program offices.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
5	Program-specific R&M requirements have had little or no influence on management of maintenance planning.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
6	Program-specific R&M requirements have had little or no influence on management of manpower and personnel.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
7	Program-specific R&M requirements have had little or no influence on management of supply support.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
8	Program-specific R&M requirements have had little or no influence on management of support equipment.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
9	Program-specific R&M requirements have had little or no influence on management of technical data.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
10	Program-specific R&M requirements have had little or no influence on management of computer resources.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$

TABLE III - Continued

Null/Alternate Hypotheses Used For Tests

Null Hyp	Null Hypothesis Statement	One-Tailed Test	Test Statistic
11	Program-specific R&M requirements have had little or no influence on management of training.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
12	Program-specific R&M requirements have had little or no influence on management of design interface.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
13	Program-specific R&M requirements have had little or no influence on management of facilities.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
14	Program-specific R&M requirements have had little or no influence on management of packaging, handling, storage and transportation.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$
15	There is no difference in the rank order ASD senior level managers and HQ USAF leadership give to the goals of the R&M 2000 Process.	N/A	See Criteria Test
16	An adequate supply of skilled and experienced R&M personnel does not exist within ASD program offices.	Ho: $p_1 = p_2 = 0.50$ Ha: A Preference Exists	Given that $\chi^2_\alpha = 2.71$; $\chi^2 > \chi^2_\alpha$
17	An immediate need for R&M education and training exists within ASD program offices.	Ho: $p_1 = p_2 = p_3 = p_4 = 0.25$ Ha: A Preference Exists	Given that $\chi^2_\alpha = 6.25$; $\chi^2 > \chi^2_\alpha$
18	The R&M 2000 Process has had little or no effect on the management of R&M in ASD program offices.	Ho: $\mu \leq 1.75$ Ha: $\mu > 1.75$	Given that $z_\alpha = 1.28$; $z > z_\alpha$

Chi-Squared. To be used for null hypotheses 16 and 17. Ordinal count data of a multinominal distribution was collected in questions 6 and 7 in support of testing of these hypotheses. The associated properties of this distribution are:

1. The experiment consists of n identical trials,
2. There are k possible outcomes to each trial,
3. The probabilities of the k outcomes ($p_1, p_2, \ldots p_k$) remain the same from trial to trial,
4. The trials are independent,
5. The random variables of interest are the counts, $n_1, n_2, \ldots n_k$ in each of the k cells (24:790), and
6. The sample size n will be large enough so that, for every cell, the expected count, $E(n_i)$, will be equal to or greater than five (24:792).

The chi-squared test statistic based on the expected outcomes of type i is stated as

$$X^2 = \frac{[n_i - E(n_i)]^2}{E(n_i)} \qquad (24:792)$$

Using k-1 degrees of freedom and a predetermined alpha, the chart X^2_α value must be less than the calculated X^2 value in order to reject the null hypothesis. Two different X^2_α values were required. The X^2 value calculated for null

hypothesis 16 was tested against a X^2_α of 2.71, based upon an α of 0.10 and 1 degree of freedom. The X^2 value calculated for null hypothesis 17 was tested against a X^2_α of 6.25, based on an α of 0.10 and 3 degrees of freedom. Given rejection of the null, criterion test considerations for the two null hypotheses must be satisfied before the Chapter I null hypotheses can be rejected. The null/alternate hypothesis pairs to be tested for acceptance/rejection in support of null hypotheses 16 and 17 can also be found in Table III.

Nominal Data and Solicited Answers. Questions 4 and 5 supplied nominal level data. With respect to this data as useful to this research, what was required was a measure of frequency of use of each of the listed categories. This data is best displayed in histogram form (24:34-39). In the case where examples are solicited, those examples served to further clarify the reason behind a given response, as well as provide a database from which additional credence was given to any drawn inferences.

Non-Response, Not Applicable, and "I Don't Know" Answers. As with any research conducted by mail survey, several answers were left unmarked, some marked "N/A" or not applicable, and some responded to with an, "I don't know," or, "I'm unfamiliar with this," response. Proper handling of these situations was necessary to maintain integrity in research results/analysis. Consequently, in

the calculation of sample means, the n value in the formula denominator reflected only the number of responses received to that question--not the total number of survey respondents (which may be less if some respondents did not answer the question). All "N/A" responses to Lickert-type questions were given a value of one. It was the researcher's opinion that "N/A" is an equivalent response to "Not Effective" or "No Influence" because if a concept/technique does not apply to a given organization's operation, it had no influence or effect upon that organization. In order to handle the "I don't know/am unfamiliar" responses, a new scale value of zero was added. All respondents who answered a question with either of the aforementioned responses were scored a zero for that response. The zero was also included in the calculation of the sample mean. This tactic was used because, based upon discussions during survey validation, it was determined by the researcher that the population targeted for this research should be familiar with all the concepts/techniques outlined for response in the survey instrument. Therefore, an "I don't know/am unfamiliar" response is a significant piece of data which should not be overlooked. A fourth anomaly was the "I do not understand the question," response. When this occurred, the answer was treated as a non-response. The researcher's rationale for this was that with the design of any survey instrument, there is always a possibility of vagueness or legitimate

lack of understanding of a question by a small percentage of respondents. It is the researcher's opinion that in this situation it would be an erroneous assumption that the respondent was unfamiliar with the concepts/techniques presented.

Criteria Tests

For survey questions one, two, eight, and nine, data was collected via 7-point Lickert scale. Question three utilized paired comparisons. Question six called for a yes or no response. Question seven was multiple choice; and questions four and five required selection(s) from a list of possible choices.

To reject null hypotheses one through four, the mean obtained by grouping the responses for all survey questions associated with that hypothesis must be statistically greater than 1.75, as proven by the resultant z-value being greater than 1.28. For Proposition 1 to be rejected, three of the four associated null hypotheses must be rejected. To reject null hypotheses five through fourteen, the mean response associated with each question must also be statistically greater than 1.75, as proven by the resultant z-value being greater than 1.28. For Proposition 2 to be rejected, six of the ten associated null hypotheses must be rejected. For null hypothesis 15 to be rejected, no difference must exist in the way HQ USAF and ASD senior managers rank the goals of R&M 2000. For

purposes of this research, a difference will exist if "increasing combat capability" was not ranked first and "decreasing costs" was not ranked last. The remaining three can differ. For null hypothesis 16 to be rejected, the proportion of all respondents who answered the associated question "yes" must be greater than 0.50. For null hypothesis 17 to be rejected, the proportion of respondents who answered "immediate" to question 7 must be less than the proportions of the other three possible responses. For Proposition 3 to be rejected, both null hypotheses 16 and 17 must be rejected. And finally, for null hypothesis 18 to be rejected, the mean response to the associated question must be statistically greater than 1.75, as proven by the resultant z-value being greater than 1.28.

IV. DATA ANALYSIS

Introduction

This chapter summarizes results from the data analysis performed on all responses to the administered mail survey. The final survey response rate was 74% (or 46 of 62). Figures 3 through 9 show the demographic breakdown of the respondents. All calculations and figures, unless otherwise indicated, are based upon total respondent group statistical analyses.

Presentation Format

Analyzed data will be organized to follow the proposition-null hypothesis order outlined in Chapter I, Figure 1. The presentation format to be used for all Lickert scale and multiple choice questions begins with a statement of the proposition in question. This is followed by the analysis of each hypothesis supporting that particular proposition. The format for the hypotheses analyses is as follows:

1. Statement of the hypothesis.
2. Survey question(s) used to measure response.
3. A statement of the findings relative to the question(s) presented in four ways:
    a. Raw scores (in tabular form), if applicable.
    b. Descriptive form (graphically).

c. Mean score, and z-value; or chi-squared and chi-squared (alpha) scores.

d. Statement of the acceptance or rejection of the null hypothesis--based upon the z-value calculated with respect to an $\alpha = 0.10$ level, and further clarified in accordance with the numeric and contextual ratings shown in Table II.

4. A general discussion of the comments made by respondents in order to substantiate the mathematical analysis.

Following the analysis of all null hypotheses for a particular proposition, a conclusions section will be used to address the issue of whether or not the criterion test designated for that proposition was satisfied to the degree required to reject it successfully. Reference to a table containing the comments of respondents on different questions is also provided.

Analysis

Table IV contains the results of all hypothesis testing conducted in this research project. It includes comparisons of means, medians, and modes, the z-, z_α -, and p-values for each null hypothesis tested, or a X^2 and a X^2_α if applicable; and a "REJECT" or "DO NOT REJECT" statement, with respect to the null hypothesis, as applicable.

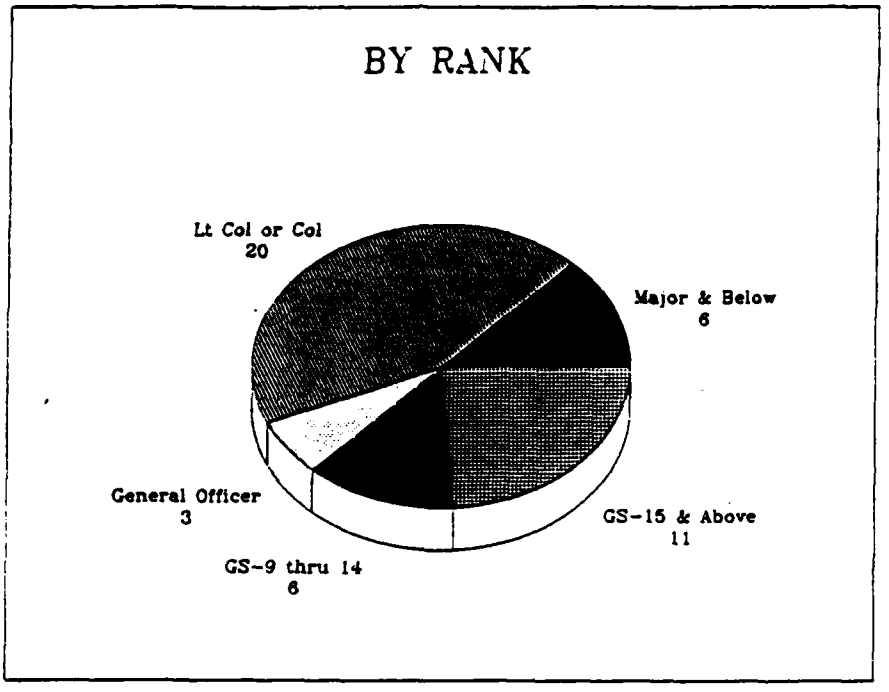

Figure 3: Respondent Demographics I

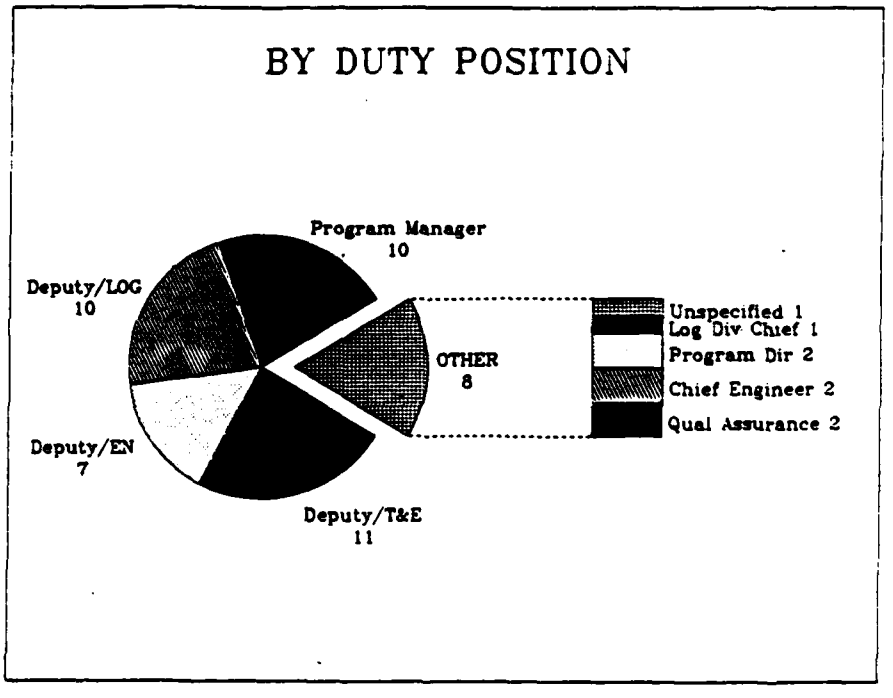

Figure 4: Respondent Demographics II

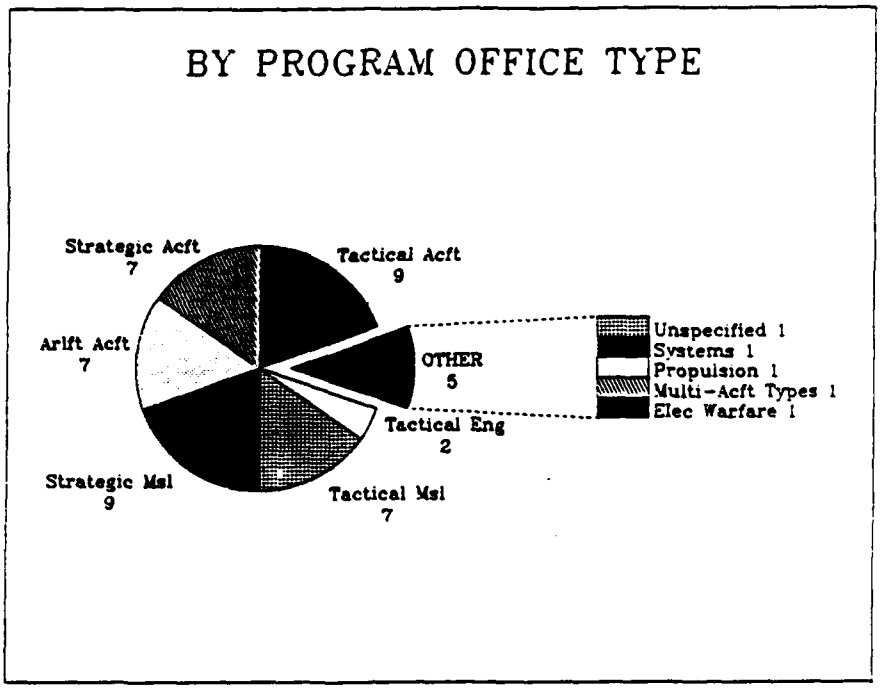

Figure 5: Respondent Demographics III

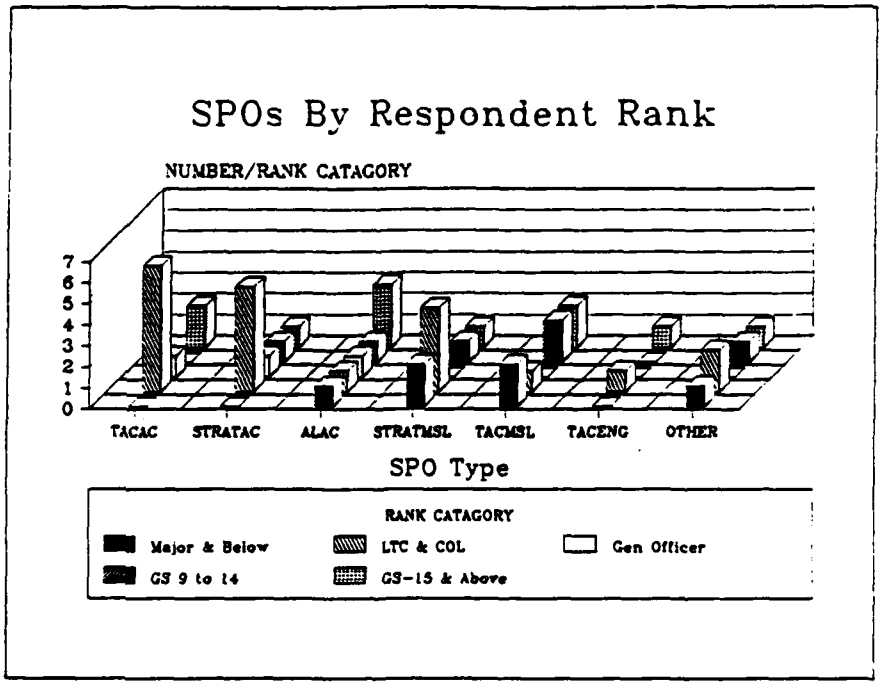

Figure 6: Respondent Demographics IV

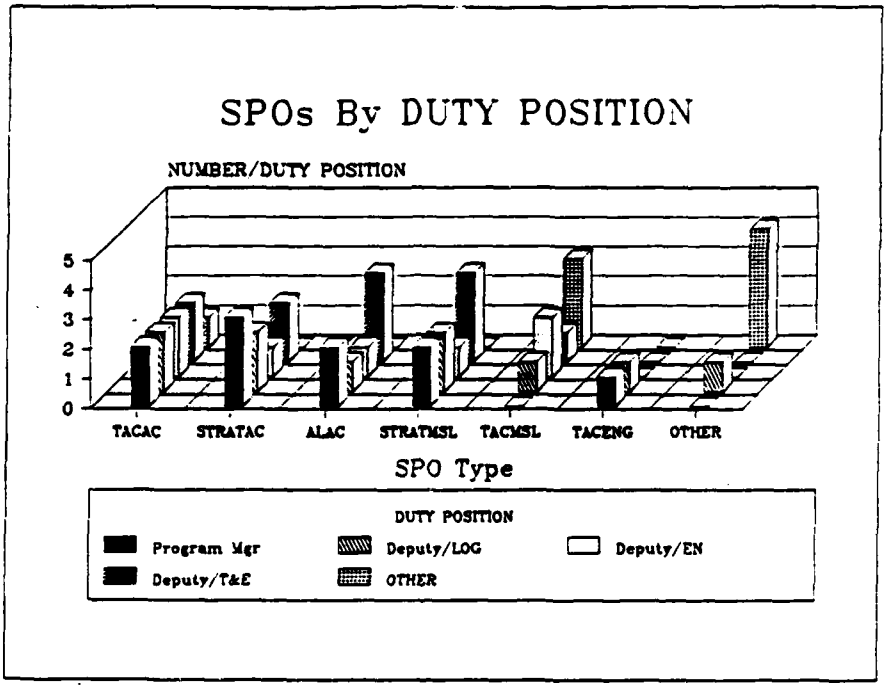

Figure 7: Respondent Demographics V

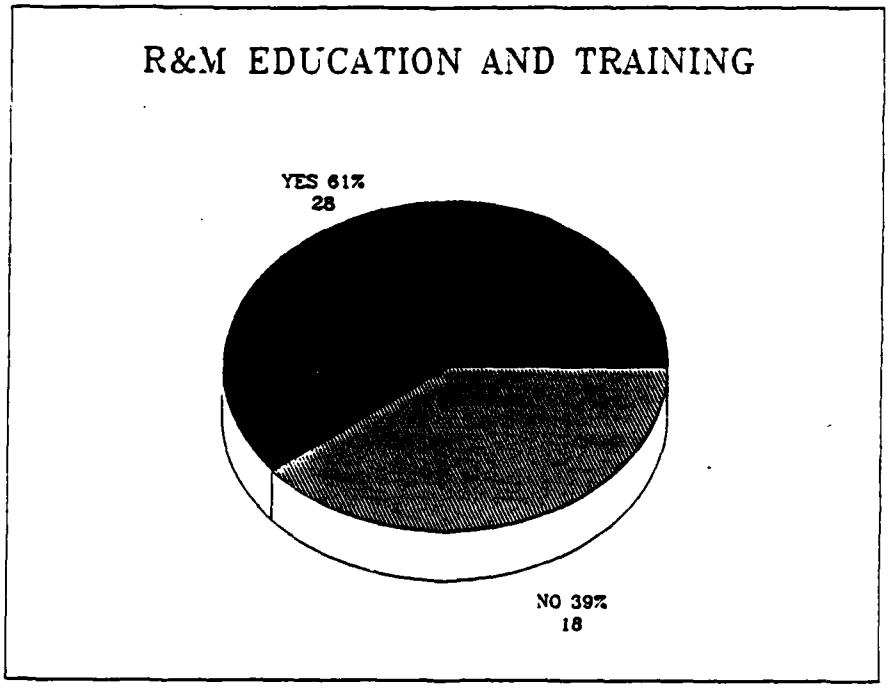

Figure 8: Respondent Demographics VI

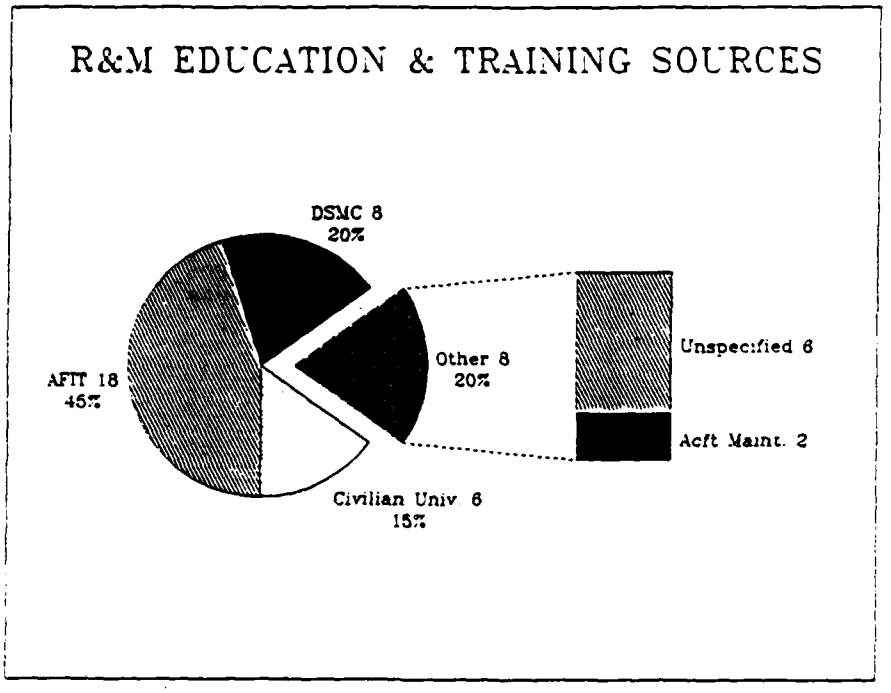

Figure 9: Respondent Demographics VII

Proposition 1. The tools of R&M management addressed in this research study have had little or no effect on achieving R&M requirements in ASD program offices (Null Hypotheses 1 through 4).

Null Hypothesis 1. R&M management tools associated with the planning function have had little or no effect on achieving R&M requirements in ASD program offices (survey questions 1a. through 1g.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 4.026$, $z = 22.032$

   c. Decision: Reject the null hypothesis

TABLE IV

HYPOTHESIS TEST RESULTS

Null Hyp #	Mean	Median	Mode	Std Dev	z - value	z_α - value	p - value	X^2- value	X^2_α- value	Reject Null?
1	4.026	4	4	1.827	22.032	1.28	0.000	---	---	REJECT
2	4.444	5	5	1.793	14.254	1.28	0.000	---	---	REJECT
3	4.188	6	4	1.809	17.874	1.28	0.000	---	---	REJECT
4	4.384	5	5	1.929	25.800	1.28	0.000	---	---	REJECT
5	4.644	5	5	1.944	9.987	1.28	0.000	---	---	REJECT
6	3.933	4	4	1.947	7.522	1.28	0.000	---	---	REJECT
7	4.267	5	5	2.071	8.150	1.28	0.000	---	---	REJECT
8	4.667	5	5	2.067	9.465	1.28	0.000	---	---	REJECT
9	4.022	4	4	1.983	7.688	1.28	0.000	---	---	REJECT
10	3.667	4	4	1.989	6.466	1.28	0.000	---	---	REJECT
11	3.778	4	4	1.987	6.845	1.28	0.000	---	---	REJECT
12	4.556	5	5	2.170	8.675	1.28	0.000	---	---	REJECT
13	3.733	4	4&5	1.802	7.385	1.28	0.000	---	---	REJECT
14	3.711	4	4	1.817	7.241	1.28	0.000	---	---	REJECT
16	---	---	---	---	---	---	---	2.81	2.71	REJECT
17	---	---	---	---	---	---	---	9.40	6.25	REJECT
18	4.465	5	5	1.804	9.742	1.28	0.000	---	---	REJECT

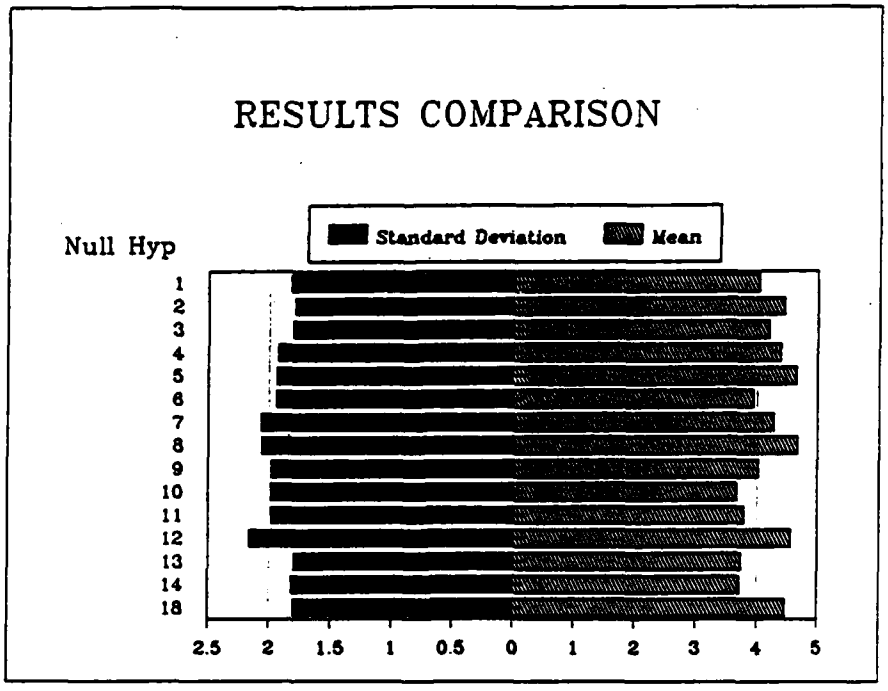

Figure 10: List Of Hypothesis Test Means and Standard Deviations

2. Comments. Using the scale presented in Table II, the respondents indicated that R&M management tools had a moderate effect on the planning function with a mean score of 4.06. The three documents which were rated highest in effectiveness by respondents were the Statement of Work (SOW), Statement of Operational Capability (SOC), and the Instructions to Offerers. However, approximately 56% of the responses in this area were rated four or lower on the Lickert scale. There were viable reasons for this. First, a large group of respondents claimed no knowledge of many of these documents. Also, many rated a document 1 or 2 if it was no longer emphasized in the present stage of their program's acquisition cycle. Finally, there were reports of several of these documents either not existing or being not applicable to programs. The document receiving the greatest number of low ratings was the MAJCOM R&M Plan.

Null Hypothesis 2. R&M management tools associated with the organizing function have had little or no effect on achieving R&M requirements in ASD program offices (survey questions 1h. and 1m.).

1. Findings.

a. Test Results: Table IV and Figure 10

b. Mean and z-value: $\bar{X} = 4.444$, $z = 14.254$

c. Decision: Reject the null hypothesis

2. Comments. Of the ten respondents who did supply an explanation for their particular responses to the questions associated with this hypothesis, most explanations were negative. Examples include a Deputy for Engineering with 18 years acquisition experience who felt SPO R&M organizations had too few people to be effective; and a DPML with ten years in acquisition who stated his SPO's R&M organization did not provide the management support needed early enough in the design stages, forcing the program office to now "scramble to recover." There were positive responses, however. Examples, here, include the comment made by a Deputy for Engineering with 24 years experience who stated that in his SPO the R&M organization is charged with keeping the designers on top of the R&M issue. Also, a Deputy for Test and Evaluation lauded his program office's R&M organization for their daily monitoring of R&M issues, which has resulted in a 90% mission capable rate.

Null Hypothesis 3. R&M management tools associated with the directing function have had little or no effect on achieving R&M requirements in ASD program offices (survey questions 1i., 1l., 1n., and 1o.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 4.188$, $z = 17.874$

   c. Decision: Reject the null hypothesis

2. Comments. Strong support was provided for all but one of the directing tools surveyed. Question 1o, which measured the timing of R&M activities, had the weakest support. Comments here ranged from, "Performance and schedule drove everything," to, "too much design detail emphasis [during] Demonstration/Validation. [This] Needs to be more focused during Full Scale Development." Yet one program manager rated the effectiveness of the timing of R&M activities at 6 stating, "the earlier, the better."

Null Hypothesis 4. R&M management tools associated with the controlling function have had little or no effect on achieving R&M requirements in ASD program offices (survey questions 1j., 1k., and 1p. through 1u.).

1. Findings.

a. Test Results: Table IV and Figure 10

b. Mean and z-value: $\bar{X}$ = 4.384, z = 25.800

c. Decision: Reject the null hypothesis

2. Comments. Strong support was provided for all controlling tools surveyed. Particularly noteworthy was the effectiveness of incentives and warranties, reliability demonstrations, and environmental stress screening in achieving program R&M requirements. Also critiqued was the author's oversight in failing to obtain a measure of the effectiveness of maintainability demonstrations in achieving program R&M requirements.

Conclusions. For Proposition 1 to be rejected, three of the four associated null hypotheses must be rejected. Since this is the case, sufficient evidence is provided to infer that tools of R&M management addressed in this research are effective in achieving R&M requirements in ASD program offices. Based on the mean score intervals outlined in Table II, a moderate degree of effectiveness is attributed to the R&M management tools addressed in this research. Table IX lists all respondent verbal comments provided with answers to survey question one.

Proposition 2. Program-specific R&M requirements have had little or no influence on the management of integrated logistics support (Null Hypotheses 5 through 14).

Null Hypothesis 5. Program-specific R&M requirements have had little or no influence on management of maintenance planning (survey question 2a.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 4.644$, $z = 9.987$

   c. Decision: Reject the null hypothesis

2. Comments. Sixty-nine percent of respondents rated maintenance planning at a level of 5 or higher in how much its management is influenced by program-specific R&M requirements. One DPML commented that maintenance support concepts are, "key to developing all the ILS elements."

This was supported by another DPML who said it, "forms the basis for decisions regarding repair level, spares, and maintenance training."

Null Hypothesis 6. Program-specific R&M requirements have had little or no influence on management of manpower and personnel (survey question 2b.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{X}$ = 3.933, z = 7.522

   c. Decision: Reject the null hypothesis

2. Comments. In this instance, 58% of all responses fell below a rating of 4 resulting in the low mean value and mid-range z-value, when compared to the other hypotheses. One Deputy for Engineering commented that, "[The] User estimates his manpower level high no matter how stringent the R&M requirements are set." It was the opinion of one DPML that, "ILS is not a viable program..." The lack of any additional meaningful respondent comments makes further analysis of these results difficult without a follow-up study designed to readdress this area.

Null Hypothesis 7. Program-specific R&M requirements have had little or no influence on management of supply support (survey question 2c.).

1. Findings.

a. Test Results: Table IV and Figure 10

b. Mean and z-value: $\bar{x}$ = 4.267, z = 8.150

c. Decision: Reject the null hypothesis

2. Comments. Six respondents provided verbal explanations of their ratings in this question. Those comments are split 50-50 with respect to the influence of program-specific R&M requirements on the management of this ILS element. The small number of meaningful comments also makes analysis of these results, beyond the hypothesis test, difficult without follow-up research.

Null Hypothesis 8. Program-specific R&M requirements have had little or no influence on management of support equipment (survey question 2d.).

1. Findings.

a. Test Results: Table IV and Figure 10

b. Mean and z-value: $\bar{x}$ = 4.667, z = 9.465

c. Decision: Reject the null hypothesis

2. Comments. Sixty-five percent of respondents felt program-specific R&M requirements earned a rating of five or higher in their influence on the management of support equipment issues. One Deputy for Test and Evaluation noted that a high degree of weapon system reliability could lead to elimination of a level of repair, thereby impacting system support equipment requirements. Since only six respondents provided comments with their

ratings, further explanation of test results were difficult to ascertain. A follow-up study appears necessary.

Null Hypothesis 9. Program-specific R&M requirements have had little or no influence on management of technical data (survey question 2e.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 4.022$, $z = 7.688$

   c. Decision: Reject the null hypothesis

2. Comments. Only three respondents chose to provide a verbal explanation for their rating in this instance. Two of the responses provided accompanied ratings of seven. The lack of accompanying respondent comments makes analysis beyond the hypothesis test and clarification of the results difficult without follow-up research.

Null Hypothesis 10. Program-specific R&M requirements have had little or no influence on management of computer resources (survey question 2f.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 3.667$, $z = 6.466$

   c. Decision: Reject the null hypothesis

2. Comments. This question had the lowest overall z-value of all survey questions. Only five respondents provided verbal support for their answers to this question.

Although it was the intent of this question to identify examples of the influence of computer resources on the management of ILS, a most interesting response came from a DPML who approached the question from the computer resource acquisition angle. He stated that although computer resources accounted for only five percent of his program office's total acquisition effort, it had one of the biggest impacts on schedule. The author's personal experience with an ongoing cruise missile acquisition program can substantiate this comment--for the ability to deliver working support software on time is very difficult. Quite often, because of the level of sophistication built-in to weapon system computer programs, contractor laboratory testing of an updated version of support software uncovers a lack of ability to perform intended functions/enhancements without degrading previously operable functions.

Null Hypothesis 11. Program-specific R&M requirements have had little or no influence on management of training (survey question 2g.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 3.778$, $z = 6.845$

   c. Decision: Reject the null hypothesis

2. Comments. Sixty-eight percent of the ratings made on this question fell at or below four on the Lickert scale. As with the previous two questions, only three

verbal responses were obtained, two of which gave ratings of six and seven. Analysis of responses to this question rendered the second lowest z-value on the survey. As with the previous two questions, very few verbal responses were provided making an assessment of the overall outcome of this question difficult.

Null Hypothesis 12. Program-specific R&M requirements have had little or no influence on management of design interface (survey question 2h.).

1. Findings.

   a. Test Results: Table IV and Figure 10

   b. Mean and z-value: $\bar{x} = 4.556$, $z = 8.675$

   c. Decision: Reject the null hypothesis

2. Comments. This question received more ratings of six and seven than any other. One Deputy for Engineering with 24 years acquisition experience called design interface, "the single biggest impact in assuring R&M is built in [to a weapon system]--not added on." Interestingly, a program manager with 10 years experience who rated the influence R&M requirements in his program had on design interface at two, stated, "it should be at 7."

Null Hypothesis 13. Program-specific R&M requirements have had little or no influence on management of facilities (survey question 2i.).

1. Findings.

a. Test Results: Table IV and Figure 10

b. Mean and z-value: $\bar{x} = 3.733$, $z = 7.385$

c. Decision: Reject the null hypothesis

2. Comments. Overwhelming support for the degree of influence R&M requirements have on management of facilities is shown by the fact that 69% of respondents rated the degree of influence at four or higher. A Deputy for Test and Evaluation noted that, "R&M suffers severely if facilities are lacking." As with three of the previous questions, there was a lack of verbal responses to this question as well. Five respondents chose to supply verbal explanations of their choice of rating. In response to the bimodality of rankings obtained in this question, the author attempted to ascertain if perhaps there was a difference in preference shown by respondents assigned to aircraft program offices vice missile and engine program offices. In other words, does one of these groups find R&M requirements for the management of facilities acquisition more influential than the other? The rationale for this is that there may have been more critical factors to consider when acquiring support facilities for one versus the other. Results indicate that there is no appreciable difference ir rating between respondents assigned to aircraft program offices vice missile and engine program offices. Therefore, the cause of the bimodality cannot be readily ascertained

without additional hypothesis testing. But it is the opinion of the author that this occurrance of bimodality is not significant for three reasons. First, it is the only occurrance of bimodality in the entire survey. Second, the values are consecutive, not separated by other rankings on the Lickert scale. And third, the values are similar to all other modal values obtained from all Lickert scale survey questions. However, a smaller standard deviation and student-t value occurred in analysis of responses from the missile/engine sample subgroup than with aircraft program office respondents. This would indicate less variability in the responses of the missile/engine subgroup than in those of the aircraft subgroup, although the difference is not significant. Table V compares the means, standard deviations, and student-t values from both sample subgroups.

TABLE V

RATING COMPARISON OF AIRCRAFT vs. MISSILE/ENGINE SUBGROUPS (FACILITIES ISSUE)

	Aircraft Subgroup	Missile/Engine Subgroup
Mean	3.696	3.647
Standard Deviation	2.055	1.658
Student-t Value	4.541	4.716

Null Hypothesis 14. Program-specific R&M requirements have had little or no influence on management of packaging, handling, storage, and transportation (survey question 2j.).

1. Findings.

a. Test Results: Table IV and Figure 10

b. Mean and z-value: $\bar{x}$ = 3.711, z = 7.241

c. Decision: Reject the null hypothesis

2. Comments. Seventy-three percent of respondents rated the influence of program R&M requirements on the management of packaging, handling, storage and transportation issues at four or higher. Unfortunately, here again only three respondents chose to supply verbal explanations of their choice of rating making it impossible to completely understand the overall rating. As with the previous hypothesis, the author wished to ascertain if in this instance a difference in overall rating would occur if the ratings of aircraft program office respondents were again compared to those of missile/engine program office respondents. The rationale for making this comparison was that packaging, handling, storage, and transportation issues may perhaps play a more crucial role in missile/engine acquisition management than in the same effort for aircraft; since aircraft effectively transport themselves from factory to flightline, but missiles and engines must be packaged for transport via a myriad of possible modes then are stored by the user for indefinite periods of times. Results indicate that here again there was no appreciable difference in rating between respondents assigned to aircraft program offices vice missile and engine program offices. As with

the previous comparison, a smaller standard deviation and student-t value occurred in analysis of responses from the missile/engine sample subgroup than with aircraft program office respondents. This would indicate less variability in the responses of the missile/engine subgroup than in those of the aircraft subgroup, although again the difference is not significant. Table VI compares the means, standard deviations, and student-t values from both sample subgroups.

TABLE VI

RATING COMPARISON OF AIRCRAFT vs. MISSILE/ENGINE SUBGROUPS (PACKAGING, HANDLING, STORAGE AND TRANSPORTATION ISSUE)

	Aircraft Subgroup	Missile/Engine Subgroup
Mean	3.652	3.765
Standard Deviation	2.146	1.641
Student-t Value	4.251	5.061

Conclusions. For Proposition 2 to be rejected, six of the ten associated hypotheses must be rejected. Based upon the responses provided, the criteria is met. Therefore, sufficient evidence is provided to infer that program-specific R&M requirements do influence the management of integrated logistics support. Based upon the mean intervals outlined in Table II, it is a moderate degree of influence. With respect to the ILS elements of facilities and packaging, handling, storage and transportation, it was shown that there is was no appreciable difference in the level of influence program R&M

requirements had on their management whether these elements were being acquired in support of aircraft, missiles, or engines. One final note of interest was that with each of the survey questions asked in support of this proposition, there were four to five respondents who consistently indicated either a lack of familiarity with ILS elements, the opinion that ILS management was not part of their particular duties, or that management of integrated logistics support was not important on their program. A list of all respondent comments to questions associated with this proposition can be found in Table X.

Null Hypothesis 15. There is no difference in the rank order ASD senior level managers and HQ USAF leadership give to the goals of the R&M 2000 Process (survey question 3).

1. Findings. Table VII shows the observed proportion of respondents preferring option a. (top of table) from each paired group to option b. (side of table). Table VIII shows the z-values related to the preference proportions of Table VII. Figure 11 depicts the interval scale derived using Thurstone's Case V model. Figure 11 highlights the rank ordering of the goals of the Air Force R&M 2000 Process as determined by survey respondents.

2. Comments. As indicated in Figure 11, "increasing combat capability" clearly ranked first among respondents. However, beyond this initial agreement with what is outlined in the R&M 2000 Process pamphlet, the

remainder of the goals of R&M 2000 were given a far different order of importance.

Ranked second by respondents was "decrease costs." The small difference in interval between these first two rankings suggests a high degree of agreed preference among respondents for seeing these two goals in this order. Additionally, the large interval between the first two and the last three rankings indicates that there is a much stronger preference for the first two goals than for the last three, with "decreasing mobility requirements per unit" being preferred least.

Conclusions. For null hypothesis 15 to be rejected, no difference must exist in the way HQ USAF and ASD senior managers rank the goals of R&M 2000. But, as indicated, the rank order determined by ASD senior managers differs from that outlined in HQ USAF's R&M 2000 Process pamphlet, and does not provide support for the hypothesis. Since no verbal clarification of why particular preferences were chosen in the paired difference test, the question remains as to why such a large difference in the ordering of these goals exists between the ASD senior managers' ranking and that of HQ USAF. The author offers two possible reasons. First, there could exist a lack of knowledge of the order of importance given to these goals by HQ USAF stemming from unfamiliarity with the concepts of the R&M 2000 process. Or, perhaps legitimately, there is a more

realistic ranking based upon the demands of the existing acquisition process, which cannot be avoided lest progress be hampered considerably. This research effort did not address this issue.

TABLE VII

PAIRED COMPARISON TEST OBSERVED PROPORTIONS

	Preferred Goal				
GOAL :	1	2	3	4	5
1 :	0.5000	0.0698	0.1429	0.0909	0.3409
2 :	0.9302	0.5000	0.2558	0.4545	0.6047
3 :	0.8571	0.7442	0.5000	0.6279	0.7500
4 :	0.9091	0.5455	0.3721	0.5000	0.8636
5 :	0.6591	0.3953	0.2500	0.1364	0.5000

How to Read: (In col. 1) Ninety-three percent of the respondents chose Goal 1 (Increase Combat Capability) over Goal 2 (Increase Survivability ...) in a paired comparison. And conversely (In col. 2), seven percent of the respondents preferred Goal 2 to Goal 1.

TABLE VIII

PAIRED COMPARISON TEST Z-VALUE AND R* TABLE

	Preferred Goal				
GOAL :	1	2	3	4	5
1 :	0.00	-1.47	-1.06	-1.33	-0.40
2 :	1.47	0.00	-0.65	-0.11	0.26
3 :	1.06	0.65	0.00	0.32	0.67
4 :	1.33	0.11	-0.32	0.00	1.09
5 :	0.40	-0.26	-0.67	-1.09	0.00
TOTAL:	4.260	-0.970	-2.700	-2.210	1.620
Mean (Z):	0.852	-0.194	-0.540	-0.442	0.324
R* :	1.392	0.346	0.000	0.098	0.864
RANK :	1	3	5	4	2

HQ USAF RANKING		RESPONDENT RANKING
Increase Combat -> Capability	- 1.39 -	<- Increase Combat Capability
Increase Survivability of the Combat -> Support Structure	- 0.98 -	
	- 0.86 -	<- Decrease Costs
Decrease Mobility Rqmnts Per Unit ->	- 0.65 -	
Decrease Manpower	- 0.35 -	<- Increase Survivability
Rqmnts Per Unit of -> Output	- 0.33 -	
	- 0.10 -	<- Decrease Manpower Rqmnts
Decrease Costs ->	- 0.00 -	<- Decrease Mobility Rqmnts

Figure 11: Paired Comparison Test Resultant Interval Scale

Proposition 3. An adequate level of R&M education and training is not available within ASD program offices (Null Hypotheses 16 and 17).

Null Hypothesis 16. An adequate supply of skilled and experienced R&M personnel does not exist within ASD program offices (survey question 6).

1. Findings.

a. Test Results: Table IV and Figure 12

b. Chi-squared score: $X^2 = 2.81$, $X^2_\alpha = 2.71$

c. Decision: Do not reject the null hypothesis

2. Comments. Based on the results of the Chi-squared test, the preferred answer to this question was "No." Fifty-nine percent of respondents provided a verbal explanation of their choice of response. Of this percentage, 74% were to the negative. The majority of these responses focused on the perceived problem of not enough manpower and/or overworked R&M engineers who spend more time documenting discrepancies than they do performing actual engineering work. Still other respondents commented on the lack of quality R&M personnel available; stating that the R&M career area doesn't draw the best people and turnover is too quick.

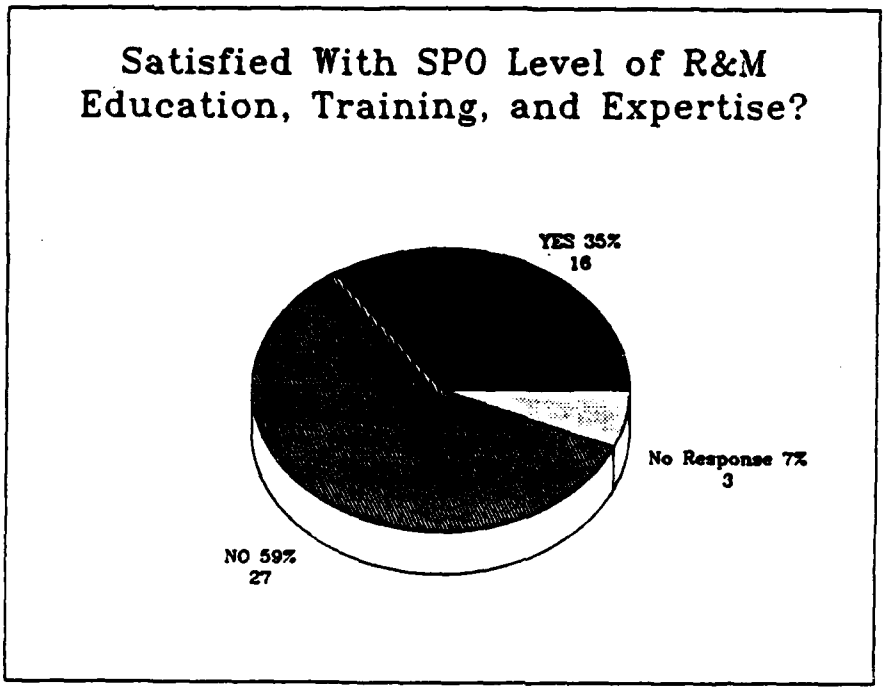

Figure 12: Survey Question Six Answer Breakdown

Null Hypothesis 17. An immediate need for R&M education and training exists within ASD program offices (survey question 7).

1. Findings.

a. Test Results: Table IV and Figure 13

b. Chi-squared score: $X^2 = 9.40$, $X_a^2 = 6.25$

c. Decision: Reject the null hypothesis

2. Comments. Based upon the results of the Chi-squared test, the answer preferred by respondents was "B," or that there is a near term need--within a year or so--for R&M education and training.

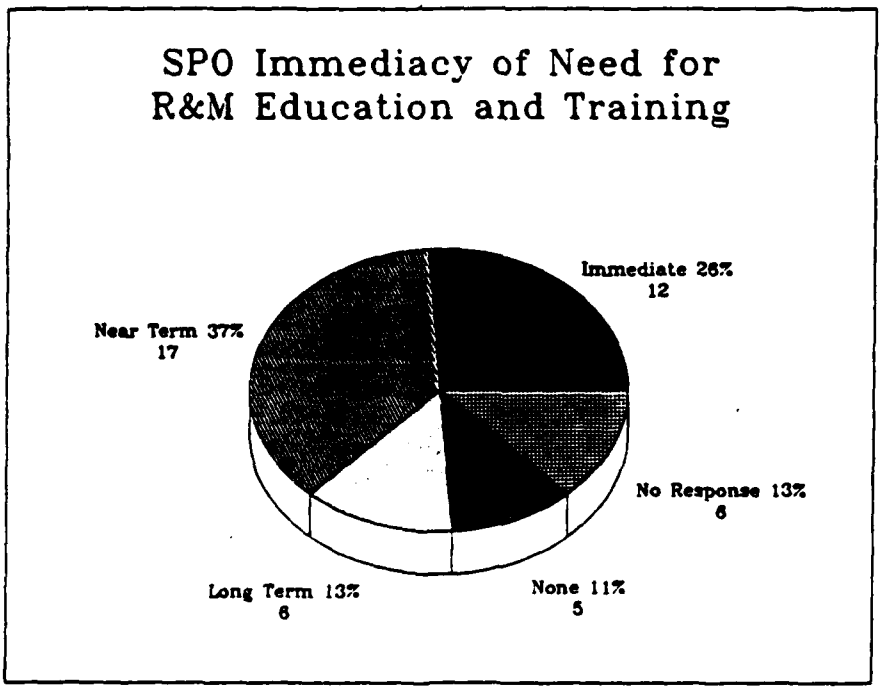

Figure 13: Survey Question Seven Answer Breakdown

Conclusions. For Proposition 3 to be rejected, both null hypotheses 16 and 17 must be rejected. Results

indicate that although senior level managers feel there is no immediate need for more R&M education and training, they did feel the supply of skilled and experienced R&M personnel was lacking. Therefore, there is insufficient evidence to infer that an adequate level of R&M education and training exists in ASD program offices. Survey questions four and five asked respondents to indicate those methods of education and training now employed in their program offices, as well as those which they felt were needed. Figure 14 graphically portrays the responses to these questions. As is indicated, the education and training tools used the most are on-the-job training (#4/5D), and symposia and mini-courses (#4/5F). Only one tool was singled out as not presently being used--namely, computer-aided tools and training (#4/5I). Interestingly, it was also the tool selected second most as being needed as an education and training aid (the most popular being in-house formal training--#4/5E). After duty hours training (#4/5G) was, by far, the least favorite tool either used or needed. The author believes that what can be inferred from questions four, five, and seven, is that although the need for education and training is not immediate, it is required; and that the way education and training is presently being done can be improved. Table XI includes a listing of all comments obtained with responses to question six.

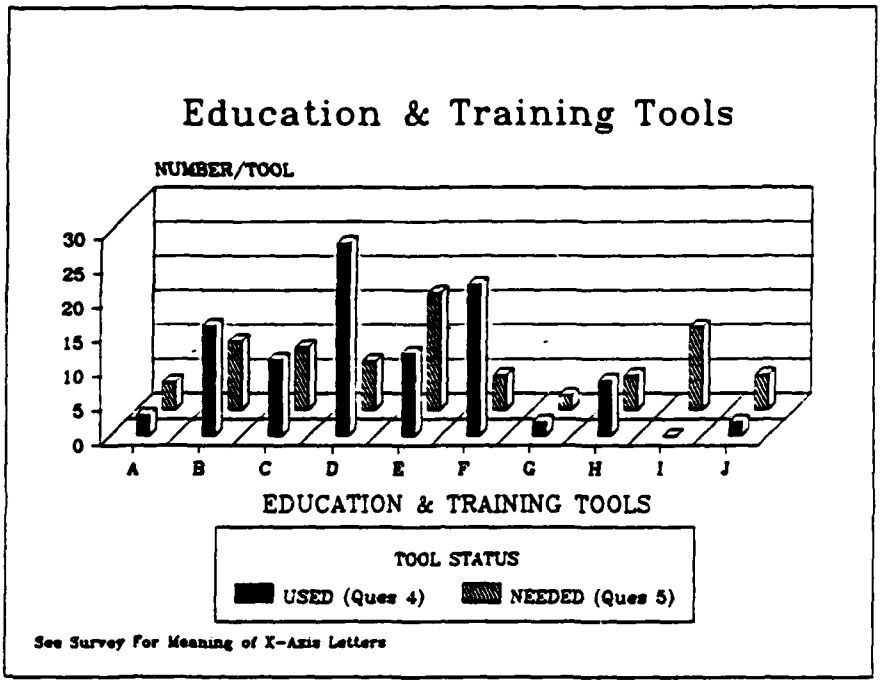

Figure 14: Survey Questions Four and Five Answer Breakdown

Null Hypothesis 18. The R&M 2000 process has had little or no effect on the management of R&M in ASD program offices (survey question 8).

1. Findings.

   a. Test Results: Table IV and Figures 10 & 15

   b. Mean and z-value: $\bar{X} = 4.465$, $z = 9.742$

   c. Decision: Reject the null hypothesis

2. Comments. Fifty-six percent of responses to this question were rated five or higher, resulting in the large z-value and strong support for the hypothesis. Fifty-two percent of the respondents provided verbal responses to this question. Although one-half of these responses spoke

favorably of R&M 2000, there were some interesting comments offered to the contrary. One Deputy for Test and Evaluation with 10 years acquisition experience stated he was unfamiliar with the R&M 2000 Process. A Deputy for Engineering with 28 years experience commented that, "no training/insight [is provided] on how to do it." A DPML with 10 years experience called the R&M 2000 Process, "just another reporting requirement." One Program Director with 36 years in acquisition stated, "We speak to R&M 2000 but show little progress towards achieving its objectives." Perhaps the feelings of these respondents was best summed up by the Deputy for Engineering with 28 years experience in acquisition who said, "Concerned personnel plus definitive design requirements, test programs, and dollar incentives make an R&M program effective."

Conclusion. For null hypothesis 18 to be rejected, the mean response to the associated question must be statistically greater than 1.75, as proven by the resultant z-value being greater than 1.28. This being the case, sufficient evidence exists to infer that the Air Force R&M 2000 Process has proven moderately effective in management of R&M requirements in ASD program offices. Table XII contains the comments obtained in defense of ratings given in response to question eight.

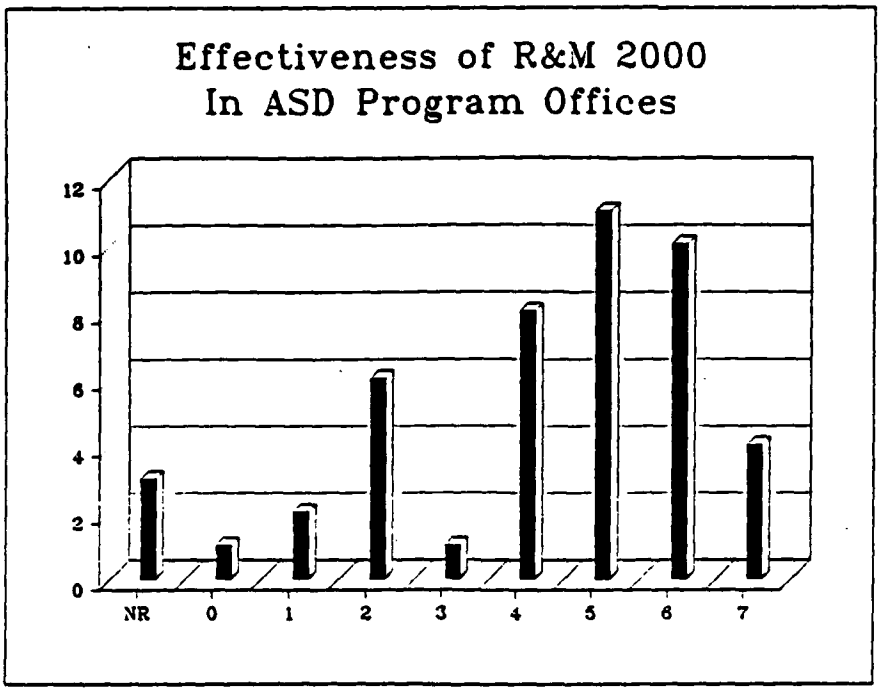

Figure 15: Survey Question Eight Answer Breakdown

Survey Question 9. In your opinion, are there any particular areas which need more emphasis in our efforts to improve R&M management in the Air Force?

1. Findings. Figure 16

2. Comments. Based on the results of a Chi-squared test, the preferred response to this question was "Yes." Thirty-one respondents provided a verbal explanation of their response to this question. Of these, 29 were explanations for a "Yes" response. Nine respondents emphasized the need for more education and training in the nuances of R&M at all levels of program management. Three respondents addressed the issue of needing more personnel

and, surprisingly, only one respondent addressed the money issue. Other responses, as well as portions of some already highlighted, offered advice/recommendations on how they felt R&M management could be improved. A Deputy for Engineering with 30 years acquisition experience suggests that we

> "train managers on how and why we should provide good management of R&M programs. Don't leave [it] up to the technical organization."

A Program Manager with 20 years experience said, "People of all backgrounds need to know the basics [of R&M]." Another Deputy for Engineering with 28 years experience suggested

> "closer coordination between the design and manufacturing functions and disciplines. Manufacturing needs to get involved sooner both at ASD and, perhaps more importantly, at the contractor's plant."

A Chief Engineer with 24 years experience commented

> "Contractor high level management has to take on the commitment to provide reliable and maintainable hardware at the beginning of a program...High level Air Force management [has] to get this message to industry...R&M 2000 has helped to accomplish this to a degree."

Also worthy of mention are the two "No" responses. The first was by a DPML with three years experience who said

> "People assigned to the R&M program would be better put to use in the SPOs. Let the program managers work R&M as required. If they need help, provide training. We must stop this stupid layered management."

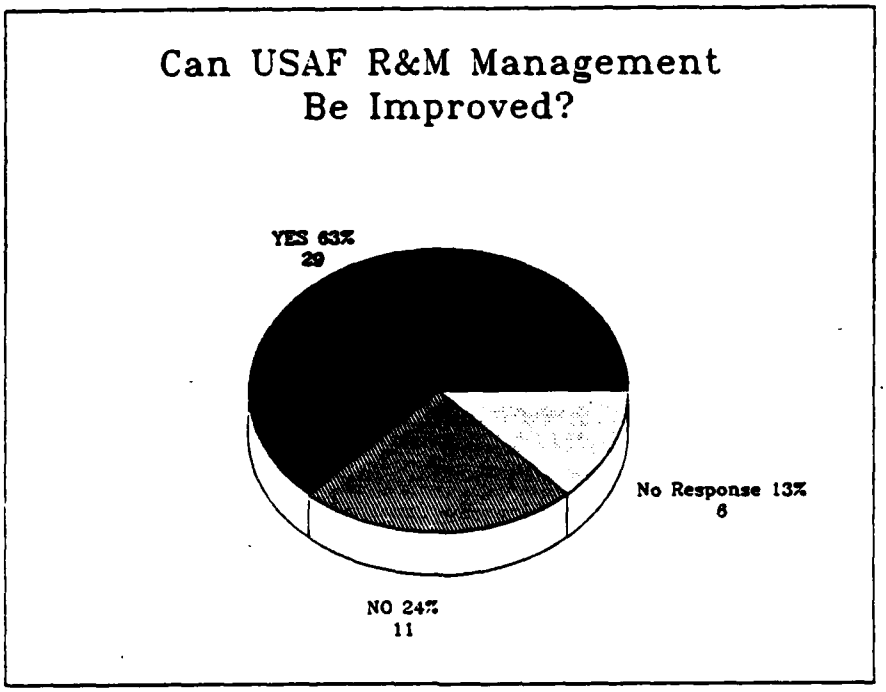

Figure 16: Survey Question Nine Answer Breakdown

The other was by a Program Manager with 10 years experience who stated

> "Too many initiatives all at once. Everyone wants to jump on the R&M 2000 bandwagon. Let's take some time to see how the next generation of weapon systems have benefitted before our next round of initiatives."

A complete list of comments make by respondents can be found in Table XIII.

V. CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the findings of this research. Findings are presented by investigative question in the order in which they were introduced in Chapter I. A summary section follows, in which a final conclusion is presented to answer the research question. Following presentation of all findings, some recommendations for further study of this topic are presented.

Question 1

Question. How do senior ASD managers feel about the effectiveness of existing R&M management tools as aids to performing functional duties?

Findings. Based upon the answers to survey question 1, it was determined that the R&M management tools presented in the survey were moderately effective as aids to performing the functional management duties of planning, organizing, directing, and controlling. Survey respondents levied their harshest criticisms on the virtual non-existence or non-use of MAJCOM R&M Plans. Two categories were rated strong overall with respect to their management effectiveness. First were the controlling tools, with the highest ratings given to the effectiveness of incentives and warranties, reliability demonstrations, and environmental stress

screening. Next were the directing tools--namely: new applications of R&M technology, R&M program constraints and trade-offs, previous R&M lessons learned, and the timing of R&M activities in relation to other program activities. Tables and figures comparing and contrasting respondent ratings to all categories and elements measured by question one can be found in Appendix B.

Question 2

Question. How are the ten integrated logistics support elements affected by increased emphasis on R&M?

Findings. Based upon the answers to survey question 2, it was determined that program-specific R&M requirements had a moderate influence on the management of integrated logistics support. The ILS element rated most influenced by program R&M requirements was design interface (mean score of 4.667). This was strongly supported by the respondents' verbal comments which accompanied some of the ratings (see Table X). Maintenance planning received the second highest mean score (4.644) with respect to the degree of influence program R&M requirements had on its management. The ILS element rated least influenced by program R&M requirements was training. See Appendix B for a comparison/contrasting of respondent ratings for all 10 ILS elements.

Question 3

Question. What priority is given to R&M 2000 goals by senior level ASD managers?

Findings. Based upon the answers to survey question 3, it was determined that ASD senior level managers placed the goals of the Air Force R&M 2000 process in a different order of priority than was outlined by HQ USAF in their R&M 2000 Process pamphlet. Placing the goal "Increase Combat Capability" first was the only source of agreement between the two groups. ASD senior managers ranked the goal "Decrease Costs" second in order of priority, in contrast to the priority it is given by HQ USAF--last. Because there was no requirement for respondent justification of choice in each paired comparison situation, the author based the findings made in this situation on the assumption that given the choices outlined in each paired comparison situation, respondents chose one over the other based upon their years of acquisition management experience and/or decisions made in similar "real life" situations.

Question 4

Question. How satisfied are senior level ASD managers with R&M education and training, and R&M expertise within their program offices?

Findings. Based upon the answers to survey questions 4, 5, 6, and 7; it was determined that ASD senior managers are not fully satisfied with the methods of R&M education

and training utilized within their program offices, nor are they fully satisfied with the amount of R&M expertise they have resident in their program offices. Many different sources of R&M education and training are being exploited in ASD program offices, the most popular being on-the-job training, and use of symposia/mini-courses. Respondents also voiced a desire to see increased use of both in-house formal training and computer-aided tools/training as means of increasing the R&M competence of program office assigned personnel. With respect to the immediacy of need for these enhancements to SPO R&M education and training activities, it was found that respondents would like to see these enhancements made within a year. This position is supported by the respondents' opinion that there is a lack of experienced R&M personnel within ASD program offices. The vast majority of verbal responses which accompanied answers to question 6 substantiate this (see Table XI).

Question 5

Question. How effective is the Air Force R&M 2000 program within ASD program offices, and how can this effectiveness be improved?

Findings. Based upon the answers to survey question 8, it was determined that respondents felt the Air Force R&M 2000 program was moderately effective within ASD program offices. Verbal responses which accompanied ratings showed approximately a 50-50 split as to its value (see Table XII).

Question 9 queried respondents as to possible additional improvements in the way R&M is managed. Suggestions included increasing the amount of R&M education and training offered, increasing the number of personnel charged with monitoring R&M activities, improving communication between designers and manufacturers, and enforcing active contractor participation in R&M improvement efforts (see Table XIII).

Summary

The Research Question. What are the attitudes of senior level managers in ASD regarding the utility of the Air Force R&M 2000 Program?

Conclusion. Based upon analysis of findings, it was determined that the Air Force R&M 2000 Process has been moderately useful in the conduct of R&M management. Some of the R&M 2000 building blocks addressed in this survey, such as reliability demonstrations, environmental stress screening, incentives and warranties--to name a few, were viewed as important tools in the fight to improve the reliability and maintainability of newly acquired weapon systems and modifications. There was, however, a significant disagreement between senior level ASD managers and HQ USAF personnel as to which goals of the R&M 2000 Process should have priority over the others. Though both groups agreed that the highest priority be given to increasing combat capability, senior level managers in ASD felt that second on the priority list should be decreasing

costs (rated the last priority by HQ USAF), vice the HQ USAF number two priority of increasing survivability of the combat support structure (rated third by senior ASD managers).

It was also noted by the author that there was a degree of non-familiarity with the R&M 2000 Process manifest by several of the respondents. This non-familiarity was identified in two ways. The first was through comments made on various surveys which stated the respondent was not familiar with the concept. The second, more subtle, clue was uncovered through reading respondent comments included with questions. The best example was Respondent #20, a DPML whose answer to question 9 infers that R&M 2000 is a program to which people must be assigned, further drawing down the number of people to work important program issues. In fact, this same individual commented that integrated logistics support is not a viable program when working in the arena of modifications. There also was the comment made by Respondent #34, a Program Director, who stated he does not have enough people, "to work any such program." Another example was Respondent #10, a Deputy for Engineering who commented that, "some policy letters have been received and implemented." Another Deputy for Engineering felt R&M 2000 was, "too difficult to implement due to lack of experienced people." Finally, there was the comment made by a DPML that R&M 2000 does not get enough, "emphasis and support from the

SPO." All these comments, in the author's assessment, point to a lack of basic understanding of what the R&M 2000 Process was designed for. One respondent commented he had received no training/insight into how to do it--the pamphlet itself provides all the insight one needs to grasp the concept. Another commented his program office dealt primarily with the purchase of off-the-shelf aircraft--but this is no excuse to overlook the importance of increased emphasis on R&M. In summary, although the R&M 2000 Process has proved moderately effective in its usefulness as an R&M management tool, there is indication of the existence of a certain degree of non-familiarity and/or misinterpretation of both what the R&M 2000 Process is and its usefulness.

Recommendations For Further Study

This section is divided into two areas which the author deemed important to emphasize--improvement of the survey instrument and specific areas where further research is required for comparing/contrasting findings.

Survey Improvement. The author feels that although the survey design proved adequate for the exploratory nature of this research project, there are several deficiencies in need of correction before the instrument should be used in a follow-on study.

Personal Data. The author failed to identify the fact that there would be a large number of Lieutenant Colonels, Colonels, and GS-15 and higher individuals

surveyed, given the level of management personnel this study reached. As a result, a less than adequate demographic breakdown of respondents, by rank, occurred. In the future, care should be taken to better identify respondents by rank.

Questions 1 and 2. The author was disappointed by the low number of verbal responses and non-responses accompanying ratings. It is the author's opinion that a degree of misunderstanding of questions may have been the reason. In the future, it may prove beneficial to include an example answer so that respondents have an idea of the direction the researcher wishes to go with the question.

Question 1. Only a limited number of the R&M 2000 building blocks were measured directly in the survey. As a result, it was not possible to get a complete measure of respondent familiarity with the concepts of R&M 2000. Since familiarity with R&M 2000 appears to be a potential area for future study, the author recommends rephrasing question one so that all R&M 2000 building blocks are included for study in the research instrument.

Areas For Future Study. As was stated in Chapter I, there are four other product divisions in Air Force Systems Command, and other organizations involved in weapon system acquisition. All are concerned with reliability and maintainability to varying degrees in varying areas of emphasis. Use of the survey instrument introduced here,

after the recommended changes are made, to measure R&M management behavior in each of these organizations would provide a wealth of information useful in shaping the type of R&M education and training needed to prepare future logisticians for their duties. The author recommends, however, that this study first be repeated in ASD in order to validate the updated survey instrument.

The author believes assessing the effectiveness of R&M management and the familiarity of managers with the tools of R&M management in each of these organizations is critical to ensuring that future weapon system acquisition endeavors do not repeat the errors of the past. It should be the goal of the acquisition community to see that a cadre of personnel is spawned with an appreciation for how emphasis on R&M early in design can improve our combat capability and survivability while reducing manpower and mobility requirements and, hopefully, life cycle costs. This is an avenue of research which should not be abandoned.

APPENDIX A

COVER LETTER AND MAIL SURVEY

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-6503

1 APR 1988

REPLY TO ATTN OF: CS

SUBJECT: R&M Management Survey (Survey Number 88-39)

TO:

1. The attached survey is part of an AFIT research project to examine the management of reliability and maintainability in the acquisition process. Your participation in this research endeavor is voluntary; but, your experience, knowledge, and expertise would certainly be appreciated and I encourage you to respond. Individual responses will be combined with others and not be attributed to you personally. For further information, contact Capt Ribuffo, AFIT/LSM, extension 55435 or his advisor, Lt Col Materna, AFIT/LSM, extension 55023.

2. Please fill out the attached questionnaire and return in the enclosed envelope by 6 May 1988.

1 Atch
Questionnaire
w/return envelope

RONALD H. TRAUDT
Colonel, USAF
Chief of Staff

USAF SCN 88-39
Expires 31 May 88

Instructions: Select only ONE answer to each question in the survey, except where instructions indicate otherwise. Mark your answers on the survey itself by simply circling the appropriate letter/number. Make additional comments at the areas provided at the specific question.

Personal Data

1. What is your present rank?

   a. Major or below
   b. Lt Colonel or Colonel
   c. General Officer
   d. GS-9 to GS-12
   e. GS-13 to GS-14
   f. GS-15 or higher

2. Time, in years, you have been involved in weapon system acquisition: _____

3. What position do you presently hold?

   a. Program Manager
   b. DPML
   c. Deputy for Engineering
   d. Deputy for T&E
   e. ILS Manager
   f. Other _____

4. Time, in years, in present position: _____

5. To which type program office are you currently assigned?

   a. Tactical Aircraft
   b. Strategic Aircraft
   c. Airlift Aircraft
   d. Training Aircraft
   e. Strategic Missile
   f. Tactical Missile
   g. Tactical Engine
   h. Other _____

6. Have you received any formal R&M management related education or training?

   a. Yes b. No

7. If you answered "Yes" to question 6, please qualify your answer:

DATE:	COURSE:	LOCATION:
_____	_____	_____
_____	_____	_____
_____	_____	_____

1. Please rate the degree of effectiveness the following areas have in achieving R&M requirements on your program:

	NOT EFFECTIVE						VERY EFFECTIVE
a. Statement of Work	1	2	3	4	5	6	7
Comments? _____							
b. Statement of Need	1	2	3	4	5	6	7
Comments? _____							
c. Statement of Operational Capability	1	2	3	4	5	6	7
Comments? _____							
d. Requirements Correlation Matrix	1	2	3	4	5	6	7
Comments? _____							
e. R&M Management Plan	1	2	3	4	5	6	7
Comments? _____							
f. MAJCOM R&M Plan	1	2	3	4	5	6	7
Comments? _____							
g. Instructions to Offerers	1	2	3	4	5	6	7
Comments? _____							

		NOT EFFECTIVE						VERY EFFECTIVE
h.	SPO R&M Organization	1	2	3	4	5	6	7
	Comments? _____							
i.	New Applications of R&M Technology	1	2	3	4	5	6	7
	Comments? _____							
j.	Collection and Use of Field R&M Data	1	2	3	4	5	6	7
	Comments? _____							
k.	R&M Management Information Systems	1	2	3	4	5	6	7
	Comments? _____							
l.	R&M Program Constraints and Tradeoffs	1	2	3	4	5	6	7
	Comments? _____							
m.	R&M Data Requirements	1	2	3	4	5	6	7
	Comments? _____							
n.	Previous R&M Lessons Learned	1	2	3	4	5	6	7
	Comments? _____							

		NOT EFFECTIVE						VERY EFFECTIVE
o.	Timing of R&M activities in relation to other program activities	1	2	3	4	5	6	7
	Comments? _____							
p.	Incentives and Warranties	1	2	3	4	5	6	7
	Comments? _____							
q.	Established R&M Measures of Merit	1	2	3	4	5	6	7
	Comments? _____							
r.	R&M Personnel Management	1	2	3	4	5	6	7
	Comments? _____							
s.	Documented Contractor R&M Policies and Practices	1	2	3	4	5	6	7
	Comments? _____							
t.	Reliability Demonstrations	1	2	3	4	5	6	7
	Comments? _____							
u.	Environmental Stress Screening	1	2	3	4	5	6	7
	Comments? _____							

2. Please rate the degree of influence program R&M requirements have on managing each integrated logistics support element:

		NO INFLUENCE						SIGNIFICANT INFLUENCE
a.	Maintenance Planning	1	2	3	4	5	6	7
	Example? _____							
b.	Manpower & Personnel	1	2	3	4	5	6	7
	Example? _____							
c.	Supply Support	1	2	3	4	5	6	7
	Example? _____							
d.	Support Equipment	1	2	3	4	5	6	7
	Example? _____							
e.	Technical Data	1	2	3	4	5	6	7
	Example? _____							
f.	Computer Resources	1	2	3	4	5	6	7
	Example? _____							
g.	Training	1	2	3	4	5	6	7
	Example? _____							

		NO INFLUENCE						SIGNIFICANT INFLUENCE
h.	Design Interface	1	2	3	4	5	6	7
	Example? _____							
i.	Facilities	1	2	3	4	5	6	7
	Example? _____							
j.	Packaging, Handling, Storage, and Transportation	1	2	3	4	5	6	7
	Example? _____							

3. Listed below are pairs of possible program management objectives. For each pair, select the one which you feel is the more important of the two in your program. Each objective will appear more than once, so consider each pair independently.

a. increasing combat capability
b. increasing survivability of the combat support structure

a. increasing survivability of the combat support structure
b. decreasing manpower requirements per unit of output

a. decreasing manpower requirements per unit of output
b. decreasing acquisition, operation, and support costs

a. increasing combat capability
b. decreasing manpower requirements per unit of output

a. decreasing mobility requirements per deploying unit
b. decreasing acquisition, operation, and support costs

a. increasing survivability of the combat support structure
b. decreasing acquisition, operation, and support costs

a. increasing combat capability
b. decreasing acquisition, operation, and support costs

a. decreasing mobility requirements per deploying unit
b. decreasing manpower requirements per unit of output

a. increasing combat capability
b. decreasing mobility requirements per deploying unit

a. increasing survivability of the combat support structure
b. decreasing mobility requirements per deploying unit

4. What is/are your program office's current method(s) for satisfying R&M education and training requirements? Circle all that are applicable.

a. None
b. Training Manuals/Books
c. Self-Study Courses
d. OJT Training
e. In-House Formal Training
f. Symposia/Mini-courses
g. After Duty Hours Training
h. College Degree Programs
i. Computer-Aided Tools and/or Training
j. Other: _____

5. In what area(s) of R&M education and training does emphasis need to be placed in your program office? Circle all that are applicable.

a. None
b. Training Manuals/Books
c. Self-Study Courses
d. OJT Training
e. In-House Formal Training
f. Symposia/Mini-courses
g. After Duty Hours Training
h. College Degree Programs
i. Computer-Aided Tools and/or Training
j. Other: _____

6. Based upon your experience, is there an adequate supply of skilled and experienced R&M personnel within your program office?

a. Yes b. No

Please Explain: _____

7. Please indicate the immediacy of need for R&M education and training in your program office:

a. Immediate.

b. Near Term (within the year).

c. Long Term (one to five years).

d. None

8. How would you rate the effectiveness of the Air Force R&M 2000 Program in your office?

NOT EFFECTIVE						VERY EFFECTIVE
1	2	3	4	5	6	7

Please explain: _____

_____

_____

_____

_____

_____

9. In your opinion, are there any particular areas which need more emphasis in our efforts to improve R&M management in the Air Force?

a. Yes b. No

Please explain: _____

_____

_____

_____

_____

_____

THANK YOU FOR YOUR COOPERATION AND ASSISTANCE!

APPENDIX B

VERBAL RESPONSES TO SURVEY QUESTIONS

TABLE IX

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	# Yrs Acq.	Rating	Response
1a.	DPML	10	5	Wasn't put together very well, but definitely the contract leverage driver [is] available.
	DPML	3	3	Program deals primarily with modifications. R&M pre-established because of use of off-the-shelf components.
	PM	10+	7	If it isn't included, you won't get it.
	DTE	1	NR	The F-16 program has been ongoing for 10+ years. I'm not aware of the relationship of the SOW to current R&M requirements.
	OTHER	8	6	*Including the specification* requirements within the contract (RFP Package).
	DPML	16	6	Most critical. If the contractor is not properly tasked for an effective R&M program, you won't have one.
	PM	10	0	I do not deal directly with program documentation at specific detail level.
1b.	DEN	24	3	Tends to be too detail design oriented. Should be focused on what is desired at the system level and not tell "how to."
	DPML	3	2	See response to question 1a.
	DTE	10	0	No knowledge.
	DPML	7	4	Sometimes watered down to limit development of non-recurring costs.
	DPML	8	5	Program in FSD. SON changes require money and new start.
	DTE	1	NR	See response to question 1a.

TABLE IX - Continued

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
1b.	OTHER	8	5	Only effective if R&M requirements are included. The majority of SONs do not include [them].
	DPML	16	3	O.K. as goes, but SONs generally treat R&M requirements as separate values with little accounting for the [relation] between them.
	PM	10	0	See response to question 1a.
1c.	DPML	8	4	See response to question 1b.
	DTE	1	NR	See response to question 1a.
	OTHER	8	5	See response to question 1b.
	DPML	16	3	See response to question 1b.
	PM	10	0	See response to question 1a.
1d.	DTE	2	1	Program has a BCM, not an RCM.
	DPML	10	2	Not really used or maintained as it should be.
	DEN	24	5	Can be effective if used at top level [and is] not detailed.
	DPML	3	2	See response to question 1a.
	DTE	1	NR	We are currently flight testing the Block 40 version on the F-16C/D. The matrix does call out goals we wish to achieve.
	PM	10	0	See response to question 1a.
1e.	DPML	10	2	Not used as a reference document as it should be.
	DEN	24	5	Plans never did anything but highlight interests. It needs to get to the designer to make him/her recognize it is their job, not somebody else's.
	DPML	3	2	See response to question 1a.
	DTE	10	0	See response to question 1b.
1f.	DTE	2	1	Non-existent.
	DPML	10	1	Not aware there is one.
	DEN	24	4	See response to question 1e.
	DPML	3	1	Not used in modifications.
	DTE	10	0	See response to question 1b.

TABLE IX - Continued

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
1f.	DTE	1	7	We have exceeded all TAF aircraft-related standards for the past several years.
	DTE	17	1	None.
	DEN	29	1	Have not seen [one].
1g.	DEN	30	7	Must have good system spec requirements, and tests or demonstrations [included].
	DEN	24	7	Showed contractors we were serious.
1g.	DPML	3	1	See response to question 1a.
	DPML	16	3	Can set the tone.
1h.	DPML	10	4	Not enough management support in early design stages. Now it's a scramble to recover.
	DEN	18	2	Too few people.
	DEN	24	5	Their primary purpose is to assure the design side of the house keeps on top of R&M.
	DPML	3	1	See response to question 1a.
	DTE	1	7	Through daily monitoring at the SPO and initiation of the "Falcon 90" Program, we have achieved, and are maintaining, a 90% MC rate on the [F-16]C/D force.
	PM	10	5	Organizational effectiveness is a direct result of the effectiveness of the people charged with the responsibility [to manage R&M].
1i.	DTE	8	2	Applications being introduced too late to be meaningful.
	DPML	10	6	Maintainability of low observables.
	DEN	24	3	I do not believe there is such a thing. R&M should be an inherent part of any new technology [that] is inseparable from the "rest of performance."
	DPML	3	1	See response to question 1a.

TABLE IX - Continued

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
1i.	DPML	7	4	Limited by real-time budget constraints despite life cycle cost savings!
	DTE	1	5	We are currently looking at radar updates incorporating R&M improvements.
	OTHER	8	6	Very effective if implemented adequately [so] as to meet specific program requirements (ie, ASD's Integrity Program).
	PM	10	0	Not observed.
1j.	DPML	10	3	Contractor still puts too much focus on pre-delivery issues at the expense of post-delivery.
	DEN	24	1	Generally, it is a tracking of what is broke. This is an endemic problem we [will] address when we start FSD.
	DPML	3	1	See response to question 1a.
	DTE	10	1	Not applicable to ATF.
	OTHER	14	3	Not much yet.
	PM	10+	7	If results are warranted.
	DTE	1	7	We collect worldwide data weekly and brief the SPO Director. We use this data to focus on problem systems and components and try to expedite parts to satisfy MICAP conditions.
	DTE	17	1	First flight [not until] Aug 1990.
	PM	10	6	We have direct access to field reports and use this data.
1k.	DPML	10	5	Classified "off-line" system isn't as flexible as it could be in [performing] trending.
	DPML	3	1	See response to question 1a.
	OTHER	14	3	Not many [to choose from] yet.
	DTE	1	7	Each unit provides their monthly maintenance summary for our reviewers.

TABLE IX - Continued

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
11.	DPML	10	2	Performance and schedule drove everything.
	DEN	24	6	All R&M trade-offs are closely tracked.
	DPML	3	1	See response to question 1a.
	DPML	7	4	See response to question 1i.
	DTE	1	5	Dollar shortfalls appear to be the greatest constraint to the program at present. We are continually reviewing [the] program to maximize [use] of resources.
	PM	10	1	Not required at this point in the program.
1m.	DPML	10	3	Too little data was required and no agreed to SPO-User-Contractor methods caused problems...
	DEN	24	2	Too much data and not enough information.
	DPML	3	1	See response to question 1a.
	DTE	1	0	Not familiar.
1n.	DPML	10	3	Contractor resists change from [his] own past practices and methods.
	DEN	24	6	Gives designers good insight. [They are] incorporated in the design database.
	DPML	3	1	See response to question 1a.
	DTE	1	6	We continually review our lessons learned from previously identified problems.
	DPML	16	4	...are more useful to tell you what not to do with old technology than how to effectively use new technology.
1o.	DPML	10	1	See response to question 11.
	DEN	24	3	Too much design detail emphasis in in a Dem/Val Program. Needs to be more focused in FSD.
	DPML	3	1	See response to question 1a.
	DTE	10	0	Not familiar with this.

TABLE IX - Continued

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	#Yrs Acq.	Rat-ing	Response
1o.	PM	10	6	The earlier the better (ie, Pre-RFP).
1p.	DPML	10	3	[Provides] no measurable contractor motivation.
	DEN	24	6	Contractors have to be told (and were) warranties will be part of the FSD contract.
	DPML	3	1	See response to question 1a.
	DTE	10	0	No knowledge.
	DPML	7	5	Again, constrained only by budget limitations.
	DPML	8	7	Nine requirements have $12 million in incentives.
1q.	DEN	24	4	Need to be tailored to the design.
	DPML	3	1	See response to question 1a.
	PM	10+	6	If [included] in specifications.
	DPML	8	1	Don't have any, other than R&M requirements and goals.
	DTE	1	0	Not familiar.
	PM	10	6	Classical measurements. Interpretation is [the] key.
1r.	DPML	10	1	Contractor personnel are "status trackers" rather than "design influencers."
	DEN	24	5	...a separate R&M personnel [section] fosters "it's not my job" attitudes by the designers. In this SPO, they are integrated.
	DPML	3	1	See response to question 1a.
	OTHER	14	5	One of the strongest.
	PM	10	NR	Every engineer has the potential to impact R&M. R&M is just good design engineering.
1s.	DPML	10	2	Too much orientation towards tracking and reporting rather than influencing and action.
	DEN	24	6	All [our] contractors have strong policies to make R&M a part of [their] engineering organization.
	DPML	3	1	See response to question 1a.

TABLE IX - Continued

VERBAL RESPONSES TO QUESTION 1

Ques. No.	Duty Title	#Yrs Acq.	Rat-ing	Response
1s.	DTE	10	0	No knowledge.
	PM	10+	6	[Effective] if used.
	PM	10	5	Got to watch [them] at the right points in the process.
1t.	DPML	10	5	Points out proof of problems not previously recognized or admitted.
	DEN	24	5	Only a small part of Dem/Val. Will receive more emphasis in FSD.
	DPML	3	1	See response to question 1a.
	PM	10+	7	[Effective] if warranted.
	DPML	8	7	[Effective.] What about M-Demos?
	DTE	1	6	All new systems being developed... must demonstrate that they meet or exceed reliability goals through testing.
	OTHER	8	6	Very effective when [you] include all the lifetime (cradle-to-grave) stresses.
	PM	10	6	If properly used, this is very effective.
1u.	DPML	10	6	Weeds out bad parts before assembly.
	DEN	24	6	[A] major emphasis in FSD.
	DPML	3	1	See response to question 1a.
	DTE	10	1	Not applicable at this point.
	OTHER	14	4	Will be strong, [tests] still being definitized.
	DPML	16	6	Good if applied correctly.
	PM	10	6	See response to question 1t.

TABLE X

VERBAL RESPONSES TO QUESTION 2

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
2a.	DPML	10	6	Forms the basis for decisions regarding repair levels, spares, and maintenance training.
	DPML	3	1	ILS is not a viable program [when dealing with] modifications.
	DTE	10	0	[I have] no knowledge of these efforts on this program.
	DPML	8	6	What level? O&I or D?
	DTE	9	0	Outside my area of knowledge.
	DTE	1	7	How the user plans to support aircraft is key to developing all the ILS elements.
2b.	DPML	10	5	[The] basis for the number of manpower slots.
	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DTE	9	0	See response to question 2a.
	DTE	1	7	R&M requirements have a major impact on the number of people required...
	DEN	28	1	[The] user estimates manpower level high no matter how stringent the R&M requirements are!
2c.	DPML	10	7	Dependent on R&M predictions (DPML doesn't always rely on contractor data, and has to make his own predictions).
	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DPML	8	6	Preplanned ILS.
	DTE	9	0	See response to question 2a.
	DTE	1	7	Depth of spares [is] determined based upon expected utilization and failure rates of components.
2d.	DPML	10	3	An outgrowth of maintenance planning.
	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DPML	8	7	Support equipment by capability.
	DTE	9	0	See response to question 2a.

TABLE X - Continued

VERBAL RESPONSES TO QUESTION 2

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
2d.	DTE	1	7	High reliability [means] a candidate for two-level repair [and] SE at the intermediate level is not needed.
2e.	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DPML	8	7	Generation from LSAR.
	DTE	9	0	See response to question 2a.
	DTE	1	7	The better the tech data, the better the supportability.
2f.	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DPML	8	5	Less than 5% of the program, but a big schedule driver.
	DTE	9	0	See response to question 2a.
	DTE	1	7	Our CDS system tracks all maintenance actions and provides the depot with needed R&M data.
2g.	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DPML	8	6	Contracted to another SPO.
	DTE	9	0	See response to question 2a.
	DTE	1	7	...MC rates continue to improve... as the learning curve goes up. You can only take advantage of the full capability of the systems if you have trained people.
2h.	DPML	10	7	[Having significant influence] is what design interface is all about.
	DEN	24	7	The emphasis that R&M is the designer's job and not logistics' or other disciplines' [has] the single biggest impact in assuring R&M is built in, not added on.
	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DTE	9	0	See response to question 2a.
	DTE	1	7	Ease of maintenance...must be considered early in [the] design stage.

TABLE X - Continued

VERBAL RESPONSES TO QUESTION 2

Ques. No.	Duty Title	#Yrs Acq.	Rating	Response
2h.	PM	10	2	[It] should be a 7.
2i.	DEN	24	3	Too early yet [for this to be an issue].
	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DTE	9	0	See response to question 2a.
	DTE	1	5	R&M suffers severely if facilities are lacking.
2j.	DPML	3	1	See response to question 2a.
	DTE	10	0	See response to question 2a.
	DPML	8	4	We have commercial items, their packaging may be different.
	DTE	9	0	See response to question 2a.
	DTE	1	7	Even the most reliable systems are degraded if the LRUs are not properly handled. This is a continual problem throughout the Air Force, regardless of the program.

TABLE XI

VERBAL RESPONSES TO QUESTION 6

Duty Title	#Yrs Acq.	Ans.	Response
DEN	30	NO	We need to train R&M fundamentals (ie, mathematics and how to prepare RFPs and specifications) and to provide OJT for the application of fundamentals.
DTE	8	YES	With [the] two-level maintenance concept ...ours should be a very easy system to field. [The] level of support appears to be adequate.
DEN	17	NO	Too many new initiatives...and not enough people to manage or even comment on them (ie, AVIP).
PM	20	NO	Never was, never will be!
DEN	28	NO	The only thing we do is document the lack of R&M! We do not put proper emphasis up front via manufacturing functional expertise.
DPML	3	NO	R&M in this SPO belongs to ASD Engineering. They are coming on line, but slower than I would like.
DPML	10	NO	[I have:] 1. a civil service projects manager with no R&M experience, 2. a DPML staff engineer with no previous R&M experience, and 3. an EN staff engineer at [the] worker level without strong management support.
DEN	18	NO	While the logistics group has no people to support R&M, there is only one R&M engineer assigned. This engineer only has time to track, and very little time to work R&M issues.
DEN	24	YES	If the engineering staff recognizes that it is their responsibility to make R&M happen, only a modest increase [in] overseers who understand the "language" is required. A gross expansion will reinforce the "it's not my job" attitude.
OTHER	3	NO	More people are needed to monitor R&M-associated testing for quick reporting of results.
OTHER	7	NO	All R&M personnel support is from the home office. To do an adequate job, a full-time individual is required [on station].

TABLE XI - Continued

VERBAL RESPONSES TO QUESTION 6

Duty Title	#Yrs Acq.	Ans.	Response
DEN	8	NO	The current opinion of the R&M career area...has not drawn the best people.
DPML	3	YES	A pool exists, however all have other areas that their attention besides R&M.
DTE	2	YES	We have a vast amount of operational experience, as well as competent logisticians.
PM	27	NO	[I] have personnel shortages across the board.
DPML	1	NO	Under the ASD reorganization, Logistics Directorate was not allowed a staff. All the specialty "experts" were absorbed into the expanded program directorates. Therefore, we lost access to experienced R&M personnel. From a logistics viewpoint, the reorganization stinks.
OTHER	14	NO	We have one--to share across three major efforts. Could use more--at least one per major effort.
DPML	8	NO	Not enough to cover vendor PDRs and CDRs. Can only manage to [the] prime [contractor] level.
OTHER	36	NO	Are there any [at all]? Answer--NO!
DTE	9	YES	Combination of engineering and projects. The engineers [have] an R&M background, the project manager is self-taught.
DTE	1	YES	The majority of my personnel have previous aircraft maintenance experience. The DPML has a large cadre of experienced R&M personnel. This all adds up to a good experience mix and serves the program well.
OTHER	24	NO	I have one R&M engineer who works with approximately 15 other engineers on a $4 billion production program with a large number of R&M changes being incorporated... One person is not enough to track the R&M data for this size program, given its dynamic nature.
DEN	28	NO	[The] quality of personnel has to be improved.

TABLE XI - Continued

VERBAL RESPONSES TO QUESTION 6

Duty Title	#Yrs Acq.	Ans.	Response
OTHER	8	NO	The majority of people who work for me are inexperienced and undertrained. [They] have to be trained through OJT and formal R&M courses... Their technical work has to be continually monitored. This process takes about two or three years... Also, it is even tougher when a manager is dealing with military [personnel who are] only with the organization two to four years.
DEN	29	NO	Only one R&M manager assigned. On a major program [it is] impossible to keep up with prime and major subcontractors even though [personnel are] always TDY. Excessive TDY detracts from adequate planning and assessment, and communication with [the] Chief Engineer and management... [This] has created a health problem requiring some time off that further aggravates [the] problem.
DPML	16	NO	There is only one in the engineering organization.
PM	10	YES	I've got all the engineers I need.

TABLE XII

VERBAL RESPONSES TO QUESTION 8

Duty Title	#Yrs Acq.	Ans.	Response
DEN	17	4	Too difficult to implement due to lack of experienced people...
DEN	28	2	No training/insight on how to do it.
DPML	3	5	Current engines are reliable and maintainable. Future engines will be [even] more so.
DPML	10	3	[This] program began before R&M 2000. But visibility of efforts has helped to motivate [the prime] contractor and subs.
DEN	18	2	Some policy letters have been received and implemented.
DEN	24	7	R&M has one of the highest priorities in the program, right after affordability and weight. Only by showing the continued high level of Air Force commitment to R&M can a SPO keep the contractors focused on this critical part of weapon system design.
OTHER	3	7	We have made the contractor believe in the R&M 2000 Program. He has seen significant [improvement] in his product because of it.
DTE	9	5	We buy primarily commercial, off-the-shelf aircraft.
OTHER	7	5	Program [management] is handled from the home office, not at [the] location where [the] work is being done.
DEN	8	6	It has had the proper effect. There is an awareness of the need for [R&M] improvements. At the current point of production, there is only so much that can be done to improve either.
DPML	3	2	Not a great need.
DTE	2	6	...R&M is effectively administered, but it is not an everyday topic of conversation in my office. Need more feedback from the people who track this effort.
PM	27	5	Effectiveness really depends on top management emphasis and support. R&M 2000 would [just] be another "-ility" without this. I believe high level emphasis is engrained in all of today's major programs.

TABLE XII - Continued

VERBAL RESPONSES TO QUESTION 8

Duty Title	#Yrs Acq.	Ans.	Response
DPML	1	2	Not enough emphasis and support from the SPO.
PM	10	7	[The] big push on R&M 2000 clearly had an impact on our contractors. They manifest continuing commitment to a more reliable maintenance design.
DTE	10	0	Not familiar [with the R&M 2000 Program].
PM	10+	7	[Ours is] considered a model program.
OTHER	4	2	We speak to R&M 2000 but show little progress towards achieving its objectives. Our efforts are primarily focused on requiring adequate reliability measures to be contracted for in ILS contracts (ie, established R&M values as targets to be met and financial penalties [levied] if not).
OTHER	36	1	[I] don't have people to work any such program.
OTHER	24	6	Dr. Halpin [ASD Asst for Product Assurance] has taken a personal interest over a number of years. This has placed emphasis on the contractor to implement the goals of R&M 2000 even when it is not on contract or written.
DEN	28	4	Concerned personnel plus definitive design requirements, test programs, and dollar incentives make an R&M program effective.
OTHER	8	6	R&M 2000 is providing R&M managers with the power to implement the necessary R&M qualitative and quantitative requirements on contract without having the program managers omitting them.
DEN	29	6	R&M 2000 emphasis, along with program reliability problems, has driven aggressive reliability program changes in the areas of testing, growth curve clarification, and tracking and definition of a coherent [R&M] program philosophy.

TABLE XIII

VERBAL RESPONSES TO QUESTION 9

Duty Title	#Yrs Acq.	Ans.	Response
DEN	30	YES	Train managers on how and why we should provide good management of R&M... Don't leave [it] up to the technical organization. Program priorities are set by program managers.
DEN	17	YES	More talented people. Too many R&M people...are cast-offs from the engineering specialties--people who can't make it. They are too bureaucratic and not innovative or thinkers. Also, need more emphasis from program management.
PM	20	YES	People of all backgrounds need to know the basics.
DEN	28	YES	Closer coordination between design and manufacturing functions... Manufacturing needs to get more involved sooner both at ASD, and perhaps more importantly, at the contractor's plant.
DPML	3	YES	Better up-front requirements.
DPML	10	YES	R&M are functions of <u>design</u>, and Air Force management tends to set [them] aside as a separate function. We need to get <u>all</u> engineers involved! It's exactly like quality--you have to build it in, not inspect it in!
DEN	18	YES	Education and training.
DPML	10	YES	R&M initiatives integrated with design.
DEN	24	YES	Stop expanding R&M as a thing separate from the basic process. More resources devoted by the Air Force to track, audit, direct, etc., specific R&M [issues] causes the contractor to develop an "it's not my job" [attitude]... The corporate Air Force needs to continually emphasize [R&M] as part of the design process and not just indulge in the "empire building" associated with a new thrust.
OTHER	3	YES	Training on available computer analysis programs.

TABLE XIII - Continued

VERBAL RESPONSES TO QUESTION 9

Duty Title	#Yrs Acq.	Ans.	Response
DTE	9	YES	Standardized test parameters and established RM&A criteria vice different [criteria] for each user.
DEN	8	YES	...education for senior level management. Without senior level management commitment, R&M is left by the wayside when performance is in jeopardy.
DPML	3	NO	People assigned to the R&M program would be better put to use in the SPOs. Let the program managers work R&M as required. If they need help, provide training. We must stop this stupid layered management.
DTE	2	YES	Communicate more specifics on how to apply R&M to particular programs, and the responsibilities of each organization.
PM	27	YES	Adequate personnel manning.
DPML	1	YES	Logistics and R&M organizations need to be given more autonomy and influence in ASD. Right now, it is no more than lip service.
PM	10	NO	Too many initiatives all at once. Everyone wants to jump on the R&M 2000 bandwagon. Let's take some time to see how the next generation of weapon systems has benefitted before our next round of initiatives.
DPML	7	YES	[Keep the] budget constant.
PM	10+	YES	More extensive use of warranties, and associated realistic demonstrations and [an] effective warranty tracking system (other than 66-1 data).
DPML	8	YES	Keep the [ASD internal affairs] newsletter coming. [Plus] more emphasis on data collection and analysis systems.
OTHER	4	YES	Education of what R&M is and how it effects life cycle costs...for program management personnel.
OTHER	36	YES	Spend more time with reasonably tailored requirements--less time trying to cram all programs into a mold.

TABLE XIII - Continued

VERBAL RESPONSES TO QUESTION 9

Duty Title	#Yrs Acq.	Ans.	Response
OTHER	24	YES	Contractor high level management has to take on the commitment to provide reliable and maintainable hardware at the beginning of a program...Air Force management [has] to get this message to industry...R&M 2000 has helped to accomplish this to a degree...
DEN	28	YES	Have more acquisition personnel with operational experience.
OTHER	8	YES	[More emphasis is needed] in the detailed implementation of ASD's integrity program, and RFP streamlining policies and guidelines. Training is needed at all levels of engineering and management.
DTE	17	YES	New programs don't benefit from other ASD programs--lessons learned are "eyewash."
DEN	29	YES	...more personnel trained in R&M program structure, trade-offs, theory and mathematics...training [for] functional engineers to familiarize [them] with R&M program goals, impacts, importance, and how to achieve high reliability in the various technical disciplines.
DPML	16	YES	More trained R&M engineers, career progression in the field, less high level "gee-whiz" programs so the workers can concentrate on...details.
PM	10	YES	Educate R&M managers about systems acquisition and program management. We don't need more policies and special interest organizations that are well intentioned but naive about the acquisition process. We need doers--not watchers and overseers.
PM	10	YES	[We need more emphasis on R&M] at the engineering/manufacturing interface.
PM	15	YES	Maintainability.

APPENDIX C

ADDITIONAL TABLES AND FIGURES FROM ANALYSIS OF QUESTIONS 1, 2, AND 8

TABLE XIV

SURVEY DATA - QUESTION 1

1a. SOW	1k. R&M MISs
1b. SON	1l. R&M Program Constraints and Tradeoffs
1c. SOC	1m. R&M Data Requirements
1d. RCM	1n. R&M Lessons Learned
1e. R&M Management Plan	1o. Timing of R&M Activities
1f. MAJCOM R&M Plan	1p. Incentives and Warranties
1g. Instructions to Offerers	1q. R&M Measures of Merit
1h. SPO R&M Organization	1r. R&M Personnel Management
1i. New Applications of R&M Technology	1s. Documented Contractor R&M Policies and Practices
1j. Collection and Use of Field R&M Data	1t. Reliability Demonstrations
	1u. ESS

	Responses											
Ques#	NR	0	1	2	3	4	5	6	7	MEAN	Z-VALUE	REJECT NULL?
1a.	1	1	1	0	1	10	14	13	5	5.04	15.635	YES
1b.	1	3	1	2	6	14	11	7	1	4.07	9.458	YES
1c.	1	3	0	3	8	13	11	5	2	4.02	9.348	YES
1d.	3	4	4	2	7	12	6	7	1	3.63	6.472	YES
1e.	2	3	0	2	4	12	12	9	2	4.36	10.370	YES
1f.	1	4	8	4	7	14	6	1	1	3.02	4.873	YES
1g.	0	4	5	3	3	8	8	12	3	4.02	7.184	YES
1h.	1	0	2	2	3	8	10	13	7	4.98	13.634	YES
1i.	2	1	4	4	5	9	7	12	2	4.18	8.798	YES
1j.	2	1	7	1	4	5	9	9	8	4.45	8.426	YES
1k.	2	1	3	1	7	10	13	8	1	4.23	10.480	YES
1l.	3	2	4	3	2	13	9	10	0	4.02	8.441	YES
1m.	1	3	3	4	5	10	12	6	2	3.91	7.861	YES
1n.	1	1	3	1	5	11	10	12	2	4.44	10.986	YES
1o.	2	3	4	1	8	6	10	8	4	4.09	7.727	YES
1p.	1	2	5	2	2	3	11	13	7	4.64	9.240	YES
1q.	0	5	4	3	3	8	13	7	3	3.89	6.916	YES
1r.	3	2	5	3	7	5	13	8	0	3.84	7.500	YES
1s.	2	4	3	2	4	10	11	9	1	3.98	7.684	YES
1t.	1	1	3	2	2	6	11	13	7	4.87	11.509	YES
1u.	0	1	3	0	1	3	14	20	4	5.13	14.328	YES

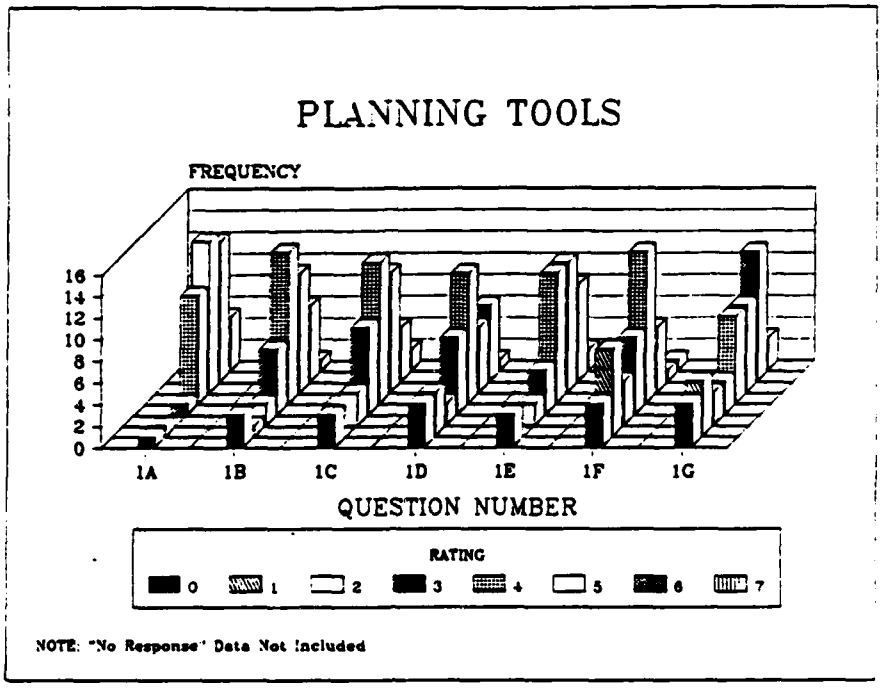

Figure 17: Question 1 Frequency Distribution I

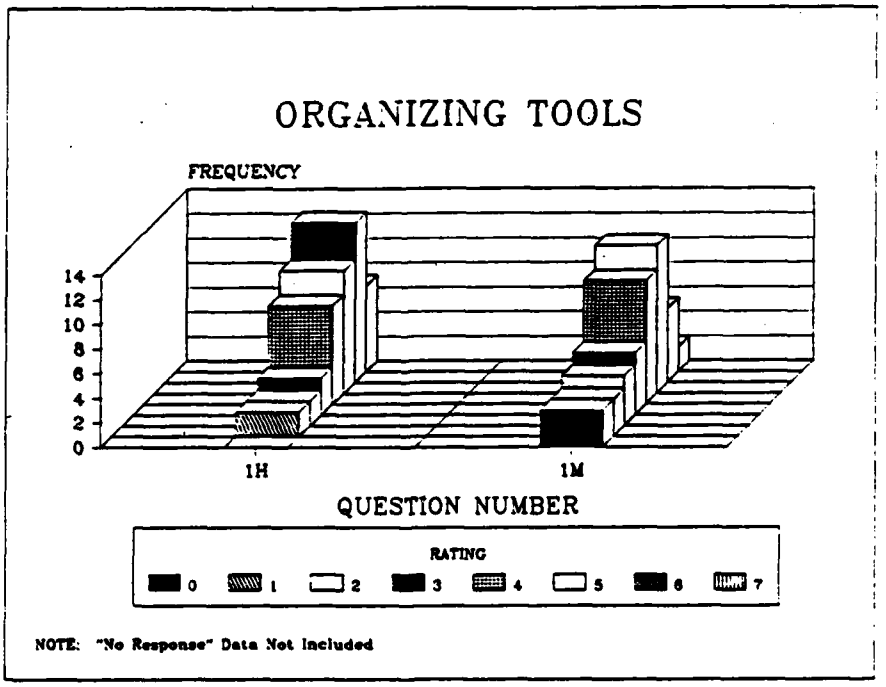

Figure 18: Question 1 Frequency Distribution II

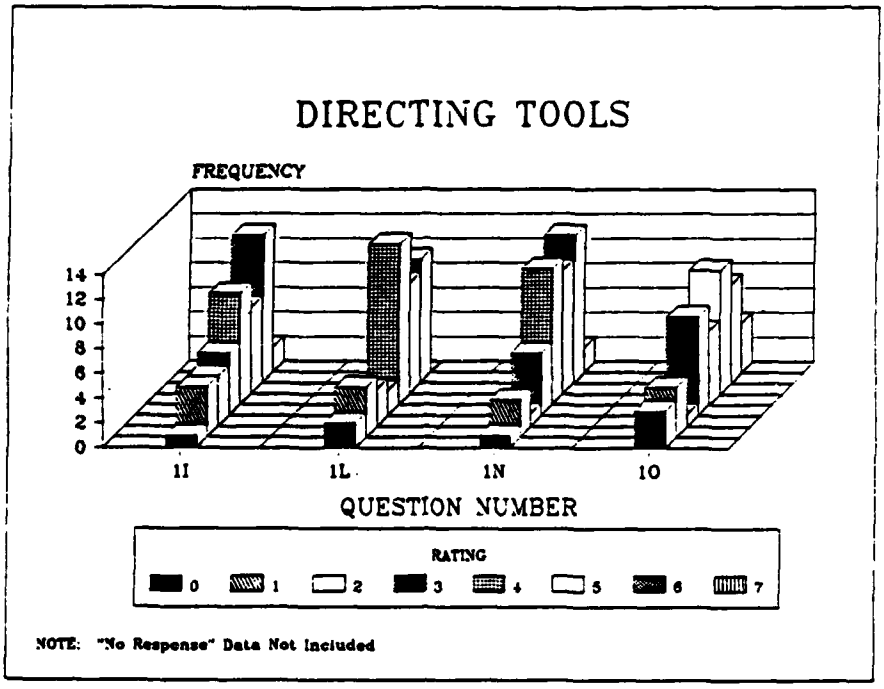

Figure 19: Question 1 Frequency Distribution III

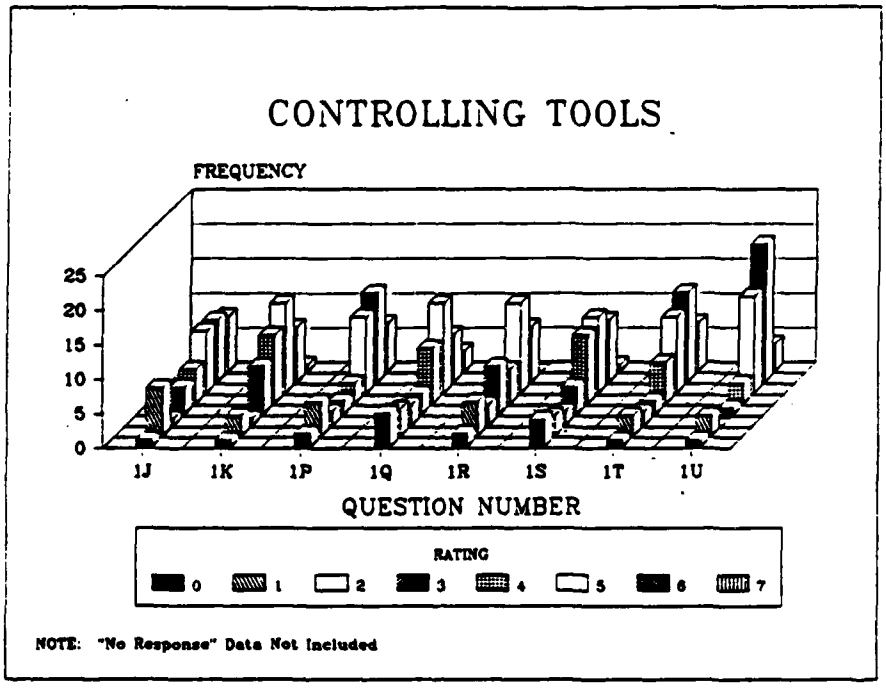

Figure 20: Question 1 Frequency Distribution IV

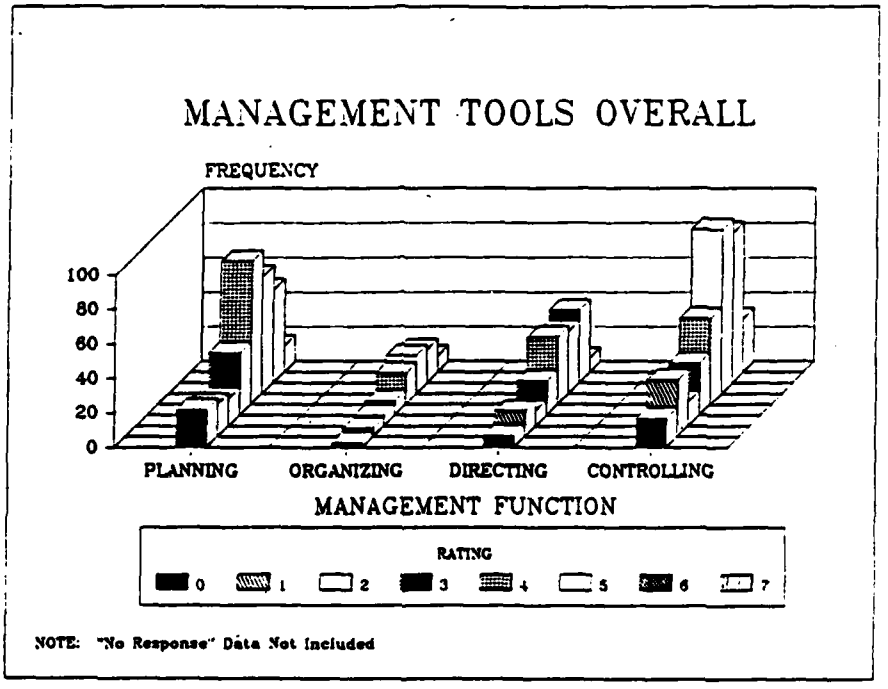

Figure 21: Question 1 Frequency Distribution V

TABLE XV

SURVEY DATA - QUESTIONS 2 AND 8

2a. Maintenance Planning (MXP)
2b. Manpower and Personnel (M&P)
2c. Supply Support (SS)
2d. Support Equipment (SE)
2e. Technical Data (TD)
2f. Computer Resources (CR)
2g. Training (TNG)
2h. Design Interface (DI)
2i. Facilities (FAC)
2j. Packaging, Handling, Storage and Transportation (PHS&T)
8. The Effectiveness of R&M 2000

	Responses											
Ques#	NR	0	1	2	3	4	5	6	7	MEAN	Z-VALUE	REJECT NULL?
2a.	1	4	1	2	1	5	15	13	4	4.64	9.987	YES
2b.	1	5	2	2	3	14	11	5	3	3.93	7.522	YES
2c.	1	5	1	2	4	9	10	9	5	4.27	8.150	YES
2d.	1	4	2	1	2	6	10	14	6	4.67	9.253	YES
2e.	1	4	4	1	4	10	11	9	2	4.02	7.602	YES
2f.	1	5	5	1	4	13	9	7	1	3.67	6.466	YES
2g.	1	5	4	1	5	11	10	8	1	3.78	6.920	YES
2h.	1	4	3	1	3	5	11	10	8	4.56	8.675	YES
2i.	1	5	3	0	6	13	13	5	0	3.73	7.303	YES
2j.	1	5	3	1	3	18	10	4	1	3.71	7.160	YES
8.	3	1	2	6	1	8	11	10	4	4.47	9.983	YES

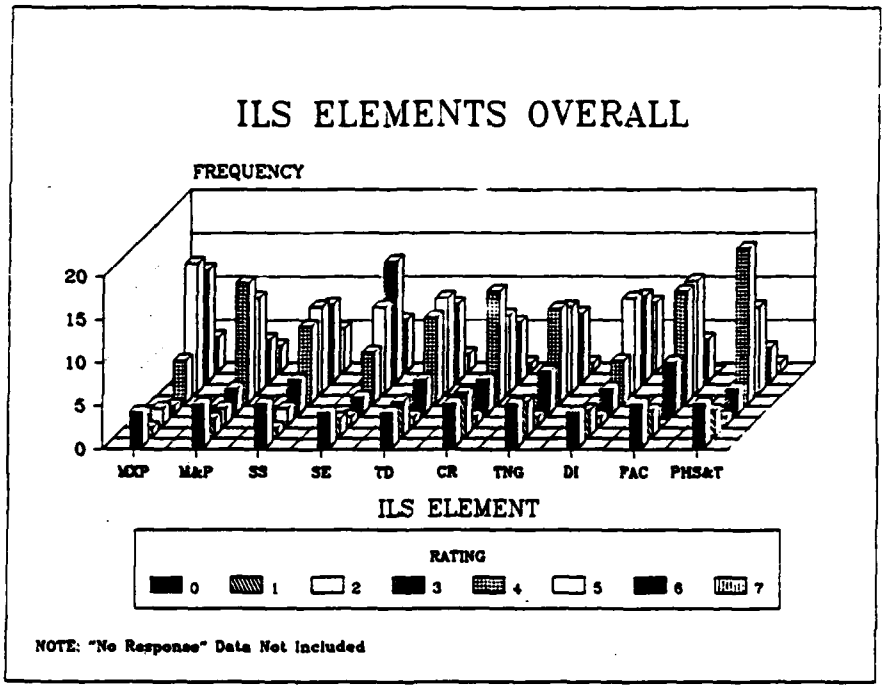

Figure 22: Question 2 Frequency Distribution

APPENDIX D

LIST OF ABBREVIATIONS

Acft	Aircraft
AFALC	Air Force Acquisition Logistics Center
AFALD	Air Force Acquisition Logistics Division
AFIT	Air Force Institute of Technology
AFMPC	Air Force Military Personnel Center
AFSC	Air Force Systems Command
ALAC	Airlift Aircraft
Arlft	Airlift
ASD	Aeronautical Systems Division
ATF	Advanced Tactical Fighter
AVIP	[ASD] Avionics Integrity Program
BCM	Baseline Correlation Matrix
CDR	Critical Design Review
CDS	[F-16] Central Data System
CERM	Center of Excellence for Reliability and Maintainability
CR	Computer Resources
Dem/Val	Demonstration/Validation [acquisition cycle phase]
DEN	Deputy for Engineering
DI	Design Interface
DoD	Department of Defense
DoDD	Department of Defense Directive
DPML	Deputy Program Manager for Logistics
DSB	Defense Science Board
DSMC	Defense Systems Management College
DTE	Deputy for Test and Evaluation
EN	Engineering
Eng	Engine
ESS	Environmental Stress Screening
FAC	Facilities
FSD	Full Scale Development [acquisition cycle phase]
HQ	Headquarters
Hyp	Hypothesis
IDA	Institute for Defense Analysis
ILS	Integrated Logistics Support
LOG	Logistics
LRU	Line Replaceable Unit
LSAR	Logistics Support Analysis Report
M&P	Manpower and Personnel
MAJCOM	Major Command
MC	Mission Capable
M-Demo	Maintainability Demonstration
MICAP	Mission Capable
MIS	Management Information System
MXP	Maintenance Planning

Msl	Missile
NR	No Response
OJT	On-the-Job Training
OSD	Office of the Secretary of Defense
PDR	Production Design Review
PHS&T	Packaging, Handling, Storage and Transportation
PM	Program Manager
R&M	Reliability and Maintainability
RCM	Requirements Correlation Matrix
RFP	Request(s) for Proposals
RM&A	Reliability, Maintainability, and Availability
SE	Support Equipment
SOC	Statement of Operational Capability
SON	Statement of Need
SOW	Statement of Work
Spec(s)	Specification(s)
SPO	System Program Office
SS	Supply Support
Std Dev	Standard Deviation
STRATAC	Strategic Aircraft
STRATMSL	Strategic Missile
TACAC	Tactical Aircraft
TACENG	Tactical Engine
TACMSL	Tactical Missile
T&E	Test and Evaluation
TAF	Tactical Air Forces
TD	Technical Data
TDY	Temporary Duty [away from home station]
TNG	Training

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Thesis Chairman: Robert D. Materna, Lt Col, USAF
Assistant Professor of Logistics Management

Approved for public release IAW AFR 190-1.

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The purpose of this study was to examine the attitudes of senior level managers in Air Force System Command's Aeronautical Systems Division regarding the utility of the Air Force R&M 2000 Program.

A survey was used to collect the research data. Findings have determined that the R&M management tools presented in the survey were moderately effective as aids to planning, organizing, directing, and controlling R&M activities. Additionally, program-specific R&M requirements had a moderate influence on the management of integrated logistics support. ASD senior managers disagreed with the priority order given the goals of R&M 2000 by HQ USAF. Also, they are not fully satisfied with the methods of R&M education and training utilized; nor are they fully satisfied with the amount of R&M expertise resident in ASD program offices. Finally, ASD senior level managers felt the Air Force R&M 2000 program was moderately effective within ASD program offices.

Deficiencies were identified and recommendations made for improvement of the design of the survey instrument prior to its reuse for future research. Also, it was recommended that other AFSC product divisions have the same survey administered to them for comparison of results.